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THE FOURTH INDUSTRIAL REVOLUTION AND ITS USE IN OTOLARYNGOLOGY

The idea that the world has entered a new phase of disruptive change has become one of the most discussed topics in boardrooms, conferences and parliaments around the world. Industry 4.0 also known as the Fourth Industrial Revolution or 4IR describes a set of ongoing and impending transformations in the systems that surround us, of which we take for granted every day.

This is a new chapter in human development driven by the increasing availability and interaction of a set of extraordinary technologies. These technologies include; Artificial Intelligence (AI) and robotics, additive manufacturing, neurotechnology's, biotechnologies, virtual and augmented reality, new materials, energy technologies and ideas and capabilities we yet don't know exist.

Apart from being just a description of technologically driven change, 4.0 is an opportunity for diverse public conversations that can help us all, from technology leaders, to policy makers, citizens from all income brackets, nationalities and backgrounds, to understand and guide the way that powerful emerging and converging technologies influence the world we live in.

Ten things we ought to know about AI today

1. AI changes over time. In today's world AI refers mostly to machine learning software such as linear regression models to decision trees, Bayesian networks, artificial neural networks and evolutionary algorithms.
2. Today's AI systems are getting rapidly better at specific well-defined tasks but lack the common sense and broader context that humans take for granted. For instance, the conversational capabilities of Apple's Siri that predicts the next word you will type is driven by task specific narrow AI.
3. AI, robots and humans work better when they work together.
4. AI systems need our help in goal setting.
5. Many of today's AI systems act as black boxes.
6. Use of AI requires individuals to store data, hence we must invest in good data management and safety programs.
7. AI can be biased and fallible.
8. AI and robotics will transform tasks rather than make humans obsolete.
9. The impact of AI and robotics depends on how we adopt them. Therefore, the way we apply both in organizations to real life problems is the primary driver of their impact.
10. AI resources are open and available online.

AI use in ENT

Since 1990s AI has increasingly been used to analyze radiological and pathological images, audiometry data and cochlea implantation performance[1-3]. Today we can use AI in our practices through;

- *Voice-based analysis:* Voice based analysis seeks to improve speech intelligibility, detect voice disorders using acoustic signals and electromyographic signals, and reduce noise experienced by patients with cochlea implants. Electromyographic signals have also been used to restore voice in patients who have undergone total laryngectomy. The AI techniques which have been used include Neural Networks (NN), k-Nearest Neighbor methods (k-NN), Support Vector Machines (SVM), Decision Trees (DT) and XGBoost among others.

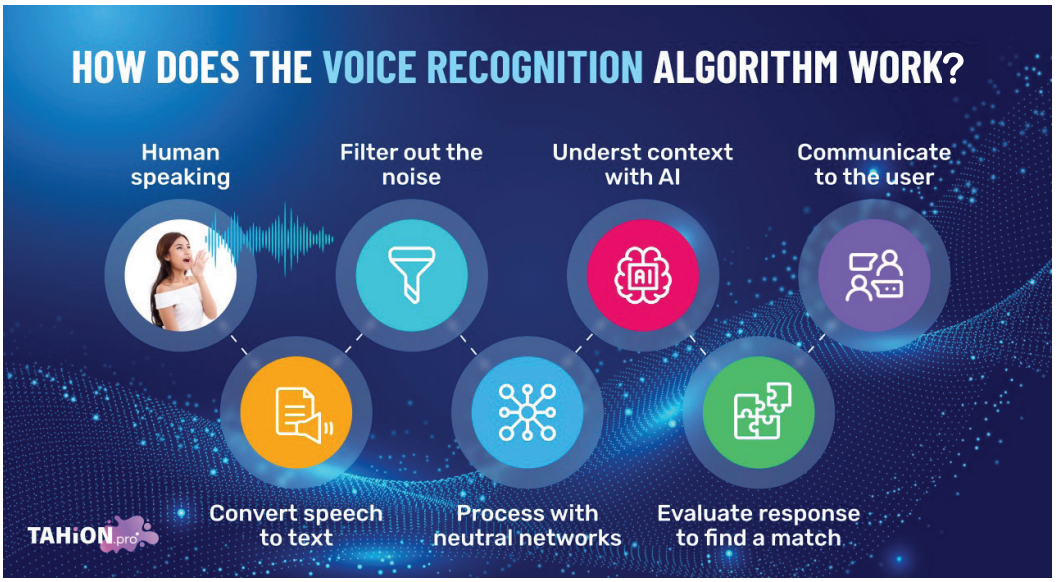


Figure 1: Voice recognition algorithms[4]

- *Medical device-based analysis:* This seeks to predict the responses to clinical treatments in order to guide physicians who wish to choose alternative or aggressive therapies. AI has been used in polysomnography to analyze raw data and improve comprehension and management of sleep disorders. AI analysis of PSG reduced time devoted to PSG hand scoring by the technician leading to a more rapid diagnosis and treatment of patients with sleep disorders and in addition reveal greater value of PSG. However the logistical challenges encountered with this is increased computer support, training mechanisms to assist providers with software integration in the sleep laboratories.
- *AI for clinical diagnosis and treatment:* AI can aid in clinical diagnosis in the following ways;

(a) Disease detection.

(b) Disease classification- using Deep Learning (DL) technology to examine images and find patterns bringing about algorithms that will assist the clinician in making quick and precise clinical diagnosis.

(c) Making efficient decision making processes.

(d) AI treatment algorithms can be used to analyze data, generate hypothesis and suggest potential differential diagnosis.

Machine learning algorithms such as logistic regression for classification, random forests and support vector machines are commonly used. Figure 2 illustrates a schematic diagram of the process cycle of using AI for clinical diagnoses and treatment.

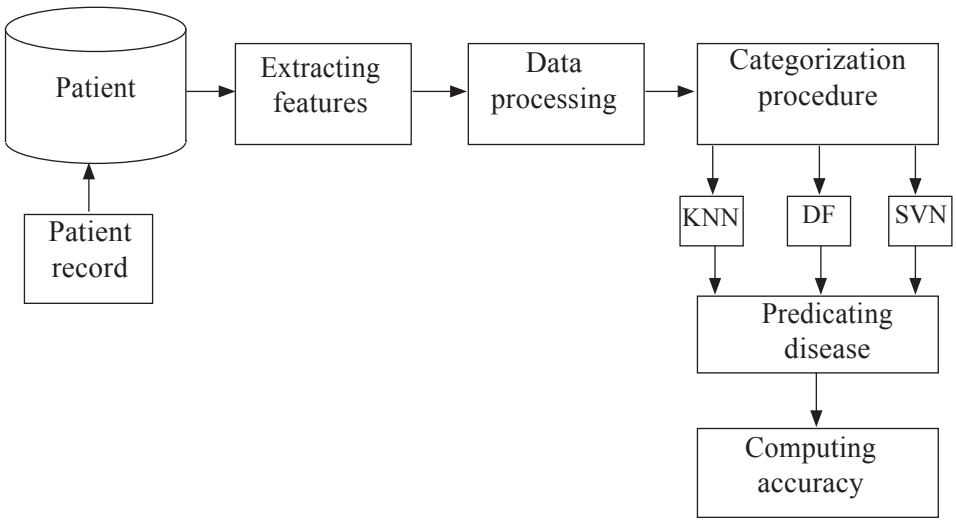


Figure 2: Machine learning system

- *AI use in interpretation of laryngoscopic images:* Deep Learning (DL) models such as SegMENT-Plus can accurately delineate laryngeal cancer boundaries in endoscopic images with performances equal to those of an otolaryngologist resident. The computation speeds of this model allows its use in videolaryngoscopies simulating real time use.

This piece just scratches the surface on how we can begin to use AI in our practices today, even as the technology keeps improving and getting more sophisticated. I therefore invite you to delve into the interesting and original research papers compiled in this issue.

Dr. Sophie Gitonga
Editor-in-Chief

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MANAGEMENT OF POSTOPERATIVE BLEEDING IN HEAD AND NECK SURGERY

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ABSTRACT

Background: Postoperative haemorrhage is among the most feared complications in head and neck surgery. It requires prompt and adequate management.

Objective: To recognize causes and management strategies of postoperative bleedings in our department.

Methods: We performed a retrospective review of all patients who presented with postoperative bleeding after otorhinolaryngologic surgical procedures in the ENT Head and Neck Surgery Department of Ouakam Military Hospital (Dakar, Senegal) over a period of 10 years.

Results: A total of 2068 ENT surgical procedures were performed during this period. They concerned tonsillectomy in 68.2% of cases, thyroidectomy in 27.3% of cases and salivary gland surgery in 4.5% of cases. Postoperative bleeding occurred in 22 (1%) cases. Sixty eight percent of these patients returned to the operating room for hemostasis under general anaesthesia. No death was recorded. The following items were suspected as contributing factors: high blood pressure (1 case), Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) use after surgery (1 case), history of peritonsillar phlegmon (1 case), tonsil stump (1 case) and hyperthyroidism (4 cases).

Conclusion: Haemorrhages after head and neck surgery are rare. They often occur in predisposed patients. Our study showed that tonsillectomy was associated with majority of the postoperative bleeding.

Key words: Head and neck surgery, Complications, Haemorrhage, Tonsillectomy, Thyroidectomy

INTRODUCTION

Postoperative haemorrhage is among the most feared complications in head and neck surgery. The incidence of postoperative bleeding after head and neck surgery has been reported to be between 0.1% and 1.6%[1,2]. Post-tonsillectomy haemorrhage is most common with a prevalence of 0.5 to 20%[3,4]. It represents a potentially life-threatening condition, especially since it occurs in a delayed manner, after the patient is discharged from hospital.

The aim of our study was to recognize aetiological factors and to describe management strategies of postoperative bleedings in our department.

MATERIALS AND METHODS

A retrospective study was conducted in the ENT Head and Neck Surgery Department of Ouakam Military Hospital (Dakar, Senegal) over a period of 10 years. All patients who experienced a postoperative bleeding complication after head and neck surgery were included. Surgical procedures and management strategies were analyzed. Potential aetiological factors were studied.

RESULTS

A total of 2068 surgical procedures were performed during this period: 1117 tonsillectomy,

795 thyroidectomy and 156 other procedures. Postoperative bleeding occurred in 22 (1%) cases; 14 (63.6%) patients were female. The youngest patient was 4 years of age and the oldest was 40 years of age (mean, 27 years).

(i) **Type of surgical procedure causing haemorrhage**

Postoperative bleeding was observed in 1.34% of cases after tonsillectomy (15/1117), in 0.75% of cases after thyroidectomy (6/795) and in 0.64% of cases after other ENT surgeries (1/156).

Depending on the performed procedure, tonsillectomy by dissection (classical blunt surgical dissection technique and hemostasis by electrocautery) was the largest provider of postoperative haemorrhage with 63.6% of cases, followed by total thyroidectomy with 22.7% of cases (Table 1).

Table 1: Distribution of postoperative hemorrhages depending on the performed procedure

Procedure	No.	(%)
Tonsillectomy by dissection	14	63.6
SLUDER tonsillectomy + adenoidectomy	1	4.6
Total thyroidectomy	5	22.7
Right loboisthmectomy	1	4,6
Enlarged submandibulectomy	1	4.6
Total	22	100

(ii) **Time to onset of postoperative haemorrhage**

Post-tonsillectomy haemorrhage was early, within 24 hours, in one case. In the remaining 14 cases, haemorrhage occurred between fourth and sixteenth day, i.e. after patients were discharged from hospital. Time to onset of compressive haematoma after thyroid surgery was less than 24 hours in 3 cases. This complication appeared after 24 hours in 3 other cases. Postoperative compressive haematoma was noted 24 hours after a submandibulectomy for and enlarged submandibular gland.

(iii) **Management**

Haemorrhage after tonsillectomy (15 patients)

- Treatment was conservative in 7 (47%) cases:
  (a) Gargling with ice serum: 5 cases;
  (b) Dabbing tonsillar lodge with a gauzesoaked in etamsylate, associated with gargling with ice serum: 1 case;
  (c) Dabbing the tonsillar lodge with a gauze soaked in etamsylate, combined with intravenous injection of etamsylate: 1 case.
- Surgical hemostasis under general anaesthesia was performed in 8 (53%) cases using:
  (a) Electrocauterization: 6 cases
  (b) Electrocauterization associated with dabbing the tonsillar lodge with gauze soaked in naphazoline xylocaine: 1 case
  (c) Pillars ligation: 1 case.
- Twelve of the 15 patients who developed bleeding after tonsillectomy were hospitalized (80%). The length of hospital stay was 24 hours.

Haemorrhage after thyroidectomy (6 patients)

- Surgical hemostasis under general anaesthesia was performed in all cases including:
  (a) Hemostasis using electrocautery of diffuse haemorrhage: 1 case
  (b) Ligation of the superior thyroid pedicle in 2 cases
  (c) Ligation of the inferior thyroid artery or one of its branches in 3 cases.
- All patients developing post-thyroidectomy haematoma were hospitalized after surgery (100%). The length of hospitalization was 48 hours.

Haemorrhage after submandibulectomy for enlarged submandibular gland (1 patient)

- Hemostasis surgery under GA consisted of facial artery ligation. A 48-hour hospitalization was required.
- A total of 15 surgical revisions under GA was performed (68.2%).

(iv) **Suspected contributing factors**

Five contributing factors were suspected:

- High blood pressure in 1 case

- NSAIDs use in 1 case (suspected because no other obvious cause was found)
- History of peritonsillar phlegmon in 1 case
- Poorly performed tonsillectomy (tonsil stump) in 1 case
- Hyperthyroidism (Graves' disease) in 4 cases.

DISCUSSION

Haemorrhage is the most common post-tonsillectomy complication, with variable prevalence in the literature, from 0.5 to 20%[3,4]. Dao *et al*[5], Téa *et al*[6] and Sy[7] found respectively rates of 2.12, 1.6 and 0.6%. Frequency of postoperative haemorrhage after tonsillectomy in our series was 1.34%.

This haemorrhage can occur in immediate postoperative period, within the first 24 hours after tonsillectomy or be delayed. Early bleeding occurs after 1.4% of tonsillectomy, most often before the eighth hour. In 0.1% of cases, it occurs between the 8th and 24th hours [8, 9]. Delayed bleeding usually occurs between 5th and 15th postoperative day, when the scabs come off. However, 30th postoperative day bleeding has been reported[9,10]. In our series, more than 90% of haemorrhages occurred between 4th and 16th postoperative day. We noted one case of immediate postoperative bleeding. Since postoperative bleeding may occur late in the postoperative course, careful follow-up for more than 15 days after the operation is needed.

Unlike bleeding from an external wound that can be controlled by manual compression, haemorrhage from a tonsillar lodge is difficult to control outside the hospital. Hence the need for prolonged monitoring beyond the period at risk. These haemorrhages occur, in the majority of cases, after postoperative hospitalization period and outside the health facility.

The management depends on the abundance of bleeding. Conservative management for post tonsillectomy bleeding could be a monitoring with ice water gargles, dabbing of the bleeding tonsillar lodge with gaze soaked in antiseptic solution. Haemorrhage may require returning to the operating room with hemostasis procedure under general anaesthesia: electrocauterization or pillar ligation.

Haemorrhage is a life-threatening complication of thyroid surgery, although it is rare, usually between 0 and 3%[11]. We found in our series 6 (0.75%) compressive haematomas. Conessa *et al*[12] had three haematomas out of a series of 155 (1.9%) thyroidectomies. Dieng *et al*[13] found 1% haematoma. Several factors can contribute to haematoma apparition, including anatomical factors, such as neovascularization and hypervascularization in Graves' disease. Indeed, the thyroid gland has a very rich vascularization, especially when there is hyperthyroidism. It is extremely important, during surgery, to carefully carry out preventive hemostasis (electrocauterization or ligation, during surgery, of any blood vessel likely to bleed) and handle the thyroid gland gently. In case of hyperthyroidism, it is important to operate only after a medical preparation whose purpose is to obtain clinical and biological preoperative euthyroidism. In Nambu *et al*[14] study, the highest percentage of patients requiring reoperation for bleeding was those with underlying Basedow's disease (4.3%). According to Furukawa *et al*[15], bleeding occurred most commonly from venules at the margin of the anterior cervical muscle and less commonly from small blood vessels around the recurrent laryngeal nerve and as oozing from connective tissue and other sites.

The most important measure in case of wound bleeding after thyroid surgery is to avoid the risk of airway stenosis. If postoperative bleeding is severe, the patient has a short neck, or the patient is obese, tracheostomy may be necessary in addition to hemostasis[15]. Some authors advocate opening the wound in the ward after airway obstruction[16]. Postoperative haematomas in thyroid surgery can be prevented by good hemostasis. Use of drains is also very beneficial.

CONCLUSION

This study reveals that postoperative bleedings are rare in cervico-facial surgery. They often occur after tonsillectomy and within predisposed patients. Close monitoring may allow early detection of potential postoperative bleeding in predisposed patients. Our study showed that tonsillectomy was associated with majority of the postoperative bleeding.

Disclosure of interest: The authors declare that they have no competing interest.

Declaration: This manuscript is published in memory of Dr. Yves Diandy.

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PATTERNS OF DISTRIBUTION OF FRONTAL RECESS CELLS AND SUPERIOR ATTACHMENT OF UNCINATE PROCESS IN PATIENTS UNDERGOING PARANASAL COMPUTED TOMOGRAPHY SCAN AT THE KENYATTA NATIONAL HOSPITAL, NAIROBI, KENYA

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ABSTRACT

Background: Frontal recess cells and superior attachment of uncinate process are key to understanding the drainage of frontal sinus and are important anatomical landmarks during endoscopic sinus surgery. The two have variable anatomical distribution patterns among individuals and are best assessed using a high-resolution computed tomography scan of the nose and paranasal sinus.

Objective: To determine the patterns of distribution of frontal recess cells and superior attachment of uncinate process in patients undergoing paranasal sinuses computed tomographic scan at Kenyatta National Hospital.

Methodology: A descriptive cross-sectional study comprising a total of 100 patients aged above 18 years undergoing nose and paranasal sinus region CT scan were recruited via convenient sampling method. Multiplanar reconstruction CT scan images were obtained and reviewed with a consultant radiologist. The patterns of frontal recess cells and superior attachment of uncinate process were documented.

Results: One hundred CT scans (200 sides) were examined. The mean age was 42 years with male: female ratio of 13:7. Out of the 200 sides, 83.5% had an Agger Nasi cell, 16.0% had a Supra Agger Nasi cell, 1.0% had a Supra Agger Frontal cell, 63.0% had a Supra Bulla cell, 6.5% had a Supra Bulla Frontal cell, 1.0% had a Supraorbital Ethmoid cell, and 2.0% had a Frontal Septal cell. In terms of the distribution of superior attachment of the uncinate process Type I 44%, Type II 6.5%, Type III 5%, Type IV 5%, Type V 17% and Type VI 22.5%.

Conclusion: Agger Nasi cell and type I attachment were the most prevalent frontal recess cell and uncinate superior attachment pattern respectively in this population.

Key words: Frontal recess cells, Superior attachment of uncinate process, Kenyatta National Hospital, International Frontal Sinus Anatomy Classification

INTRODUCTION

Frontal sinus, one of the four paranasal sinuses, is a paired, anterior sinus situated between the two diploe of frontal bone, deep to the medial part of superciliary arch. It can be viewed as a complex structure having four parts: infundibulum, frontal sinus recess, sinus and frontal ostium. During surgery, these structures and their relationship to the uncinate process are important landmarks. Its anatomy is challenging to surgeons as well as radiologists[1].

Various ethmoidal cells occupy the frontal sinus recess, affecting the drainage pathway of the frontal sinus. Several classification systems have been proposed in order to understand these cells and better characterize the frontal sinus drainage pathway. Despite the fact that these nomenclatures have boosted our ability to describe the anatomy of frontal sinus recesses, many of these systems have deficiencies, such as intrinsic discrepancies,

subjective interobserver variations, or even inadequate anatomical details[2]. Through technological advances in endoscopic visualization and high-resolution computed tomography scans, we are now better able to understand the anatomy of the frontal sinus recess[3].

Within the past few decades, there has been an increase in the number of frontal sinus surgeries and interest in refining the surgical approaches. In addition, endoscopes, preoperative computed tomography scans, and intraoperative navigation systems are commonly used. Due to its proximity to the brain, orbit, vascular structures such as the anterior ethmoidal artery, and its likelihood of causing iatrogenic complications like sinus stenosis, the frontal sinus has been considered the most challenging and risky sinus to operate[2]. Frontal sinus surgery aims to restore ventilation and drainage. In order to achieve this, ethmoidal disease blocking the frontal sinus recess needs to be identified and removed. Additionally, failure of endoscopic sinus surgery has been linked to anatomical causes, including persistent frontal sinus recess obstruction of the frontal sinus recess. This failure is commonly caused by the anatomical complexity of the frontal sinus recess[4]. In order to ensure the safety of the patient during a complete dissection, it is imperative that the surgeon has a clear understanding of the frontal sinus recess cells[5]. For safe Endoscopic Sinus Surgery (ESS), one must understand normal anatomical variations[1]. Endoscopic intranasal approach has gained favor over the external surgical approaches but sometimes both approaches can be indicated[6].

Classification of frontal recess cells

Over the years, different classification systems have been proposed for frontal sinus recess cells. Based on cadaveric studies, Van Alyea was the first person to introduce the concept of grouping frontal cells. In line with his findings, frontal cells can be divided into two anatomical types: Frontal sinus recess cells and invading frontal cells. A frontal sinus cell is one that originates in the frontal sinus recess and extends there, whereas an invading frontal cell is one that invades the frontal sinus recess regardless of origin. Subsequently, he sub-classified the two broad groups. Cells in the anterior recess were divided into three groups based on how they expanded: anterior extension of the recess; small cells (small and proportionate but poorly developed and rudimentary); and wide and shallow cells. These invader subgroups included: cells that arose in the frontal sinus recess and pneumatized into the frontal sinus, inter-sinus cells, infundibular, supra-infundibular, and ethmoid bulla cells[7].

Four types of frontal cells were identified by Bent and Kuhn in 1994. Type I was a single recess cell seen above the Agger nasi cell, while Type II was composed of two or more recess cells above the Agger nasi cell. Both were best seen in coronal sections of CT scan and could extend up into the frontal sinus. Additionally, they are distinguished from Agger nasi cells by their superior location and being inferior to the frontal sinus floor. Type III consisted of a large frontal sinus recess cell pneumatizing superiorly into the frontal sinus. Type IV is confined wholly within the frontal sinus with its volume varying significantly sometimes appearing like an air bubble within an otherwise opaque frontal sinus or as a cell within a cell[6].

Lee *et al*[8] described frontal sinuses and frontal sinus recess cells anatomy in 50 adults without known frontal sinus disease using high resolution tri-planar CT images[8]. The frontal sinus and recess were functionally defined based on anatomical descriptions and current imaging modalities, from the perspective of a surgical endoscopist. The ten types of cells were described along with the CT scan planes on which they appear best. These cells included Agger Nasi Cell (ANC), Frontal Cells - Type I-IV (FC I-IV), Supraorbital Ethmoidal Cell (SOEC), Frontal Bullar Cell (FBC), Supra-Bullar Cell (SBC), Inter-Frontal Sinus Septal Cell (IFSSC) and Recessus Terminalis (RT)[7]. Because of the addition of as yet unrecognized cell types, this system was an improvement over Bent and Kuhn. Despite this, it only gives the nomenclature of the frontal sinus recess cells without clearly indicating their location at a glance.

Since then, other suggestions have been made on classification. In the European Position Paper on Anatomical Terminology for the Internal Nose and Paranasal Sinuses, cells were classified as anterior, posterior, medial, and lateral[9]. Although it gives surgeons a good idea of where a cell is located, it does not provide enough information about the cellular relationships within this region to allow them to plan better[10].

Based on the work of the authors mentioned above, the International Frontal Sinus Anatomy Classification (IFAC), 2016 set forth a new consensus classification system for frontal sinus anatomy. This was in an attempt to have a classification system that took into account the number and position of cells, as well as how that impacted the pattern of frontal drainage. A system such as this will also enhance understanding of the surgical anatomy and methods

used in approaching the frontal sinus recess and its surrounding area. There are three groups of cells in the frontal sinus recess: anterior, posterior, and medial. Each class has specific cell names and how it is defined. There are three types of cells in the anterior region: Agger, supra-agger, and supra-agger frontal cells. Suprabulla cell, suprabulla frontal cell, and supra-orbital ethmoidal cell are the posterior cells, while the medial cell only has the frontal septal cell. In addition, endoscopic sinus surgery is graded on a scale of 0 to 6 according to the extent of the surgery. In grades 0 and 3, the frontal sinus recess is surgically operated on, rather than the frontal sinus itself, while grades 4 and 6 require bone removal to enlarge the frontal ostium[10]. This is the most current system that is being adopted and the grading system has been recommended for use in graduated form of surgical training and communication amongst surgeons operating in the nose.

Classification of superior attachment of uncinate process

In frontal sinus recess surgery, the superior attachment of the uncinate process is a vital anatomical landmark[11]. During ESS the uncinate process is the first structure to be removed. Individuals with chronic sinusitis are reported to experience its anomalies the most frequent[12]. It therefore underscores the need for proper dissection in the frontal sinus recess, adequate exposure of the frontal sinus, as well as the minimization of risks and complications during surgery. Owing to high quality CT scan images, the anatomical variations can be detected pre-operatively.

Understanding the uncinate process and more specifically its superior attachment is therefore important for any surgeon operating in the nose and paranasal sinuses.

Classification of superior attachment of uncinate process

There are two main classification systems for the Superior Attachment of the Uncinate Process (SAUP). The superior attachment of the uncinate process was first classified in 1991 by Stammberger and Hawke into three patterns: attachment to the lamina papyracea (Type I), attachment to the skull base (Type II), and attachment to the middle turbinate (Type III). However, they did not describe other extensions or combinations of extensions and their prevalence. In 2001, Landsberg and Friedman categorized the superior attachment into six patterns[11].

Imaging for the nose and paranasal sinus

The initial preferred imaging modality for the nose and paranasal sinuses is a CT- scan. This will help delineate the normal anatomy as well as depict pathologies when present. For maximum exploitation of this modality, a tri-planar view with several reconstruction options are available from the axial cuts; recommended is less than 2mm reconstruction slices. A computer work station installed with appropriate multiplanar viewer improves reliability[1,4–6].

Generally, the indications for sino-nasal CT scanning include: evaluation for sino-nasal infectious or inflammatory diseases, sino-nasal tumours, trauma and cerebrospinal fluid leaks. For this anatomical study, paranasal reconstruction images were used.

MATERIALS AND METHODS

This was a descriptive cross-sectional study. The main objective was to determine the patterns of distribution of frontal recess cells and superior attachment of uncinate process in patients undergoing paranasal CT-scan at KNH. The specific objectives were to describe the demographic features of patients undergoing paranasal CT-scans, to classify the pattern of distribution of frontal recess cells according to IFAC and to describe the pattern of superior attachment of uncinate process using the Landsberg and Friedman classification system in patients undergoing paranasal CT-scans at KNH.

The study was conducted at the KNH ENT and Radiology Departments between January and December 2021. One hundred patients were recruited using convenient sampling method. The study population included patients scheduled for head and neck CT scan with nose and paranasal sinus Multi-Planar Reconstruction (MPR). The inclusion criteria were all patients aged 18 years and above, who had been scheduled for head and neck CT scan with nose and paranasal sinus multi-planar reconstruction at KNH during the study period and consented to the study. The exclusion criteria were patients with destructive paranasal disease obliterating sino-nasal anatomy, specifically FSDP; patients who have undergone prior sinus surgery; patients who have consented but whose CT-scans have significant artifacts which interferes with interpretation of the paranasal anatomy and patients with congenital anomalies affecting the FSDP. Sample size was calculated using WHO formula extracted from

WHO's sample size determination of prevalence in health studies[13].

Patients' demographic data was entered into the data collection sheet after getting consent. All CT scans done were saved in a DVD disk to be evaluated by the principal researcher in conjunction with a consultant radiologist at the Department of Radiology work station.

The computed tomography scan machine employed at KNH was Neusoft 64 Slice CT, Model: NeuViz 64In, SN: N64IN170152E manufactured by Neusoft Medical Systems taking standard axial scans by helical technique (140kV, 250mA, rotation time of 0.75 seconds, routine section thickness of 1mm with 1mm reconstructions) with an inbuilt viewer. Head and neck CT scans used similar protocol as pure paranasal sinus CT scans with axial cuts of 1mm and possibility of MPR reconstructions of 1mm.

RESULTS

Demographic data

Distribution of patients according to gender and age

The mean age and sex distribution of the patients in the study are as shown in Table 1.

Table 1: Demographic characteristics

Variable	n (%)
Age in years	
Mean (SD)	42.0 (17.5)
Min-max	18.0-89.0
Sex	
Male	65 (65.0)
Female	35 (35.0)

Patterns of frontal recess cells according to International Frontal Sinus Anatomy Classification (IFAC)

Out of the 200 sides examined, Agger nasi cells were found in majority of the CT scans, contributing 83.5%. The right had 81% and the left 86%. SBC was second most common cell encountered at 63% with right side having 59% and left 67%. SOEC and SAFC were the least common cells at 1% each with right side having 0% and left 2% for SOEC and 2% vs 0% right vs left for the SAFC respectively. The other distribution is as shown in Table 2 and Figure 1.

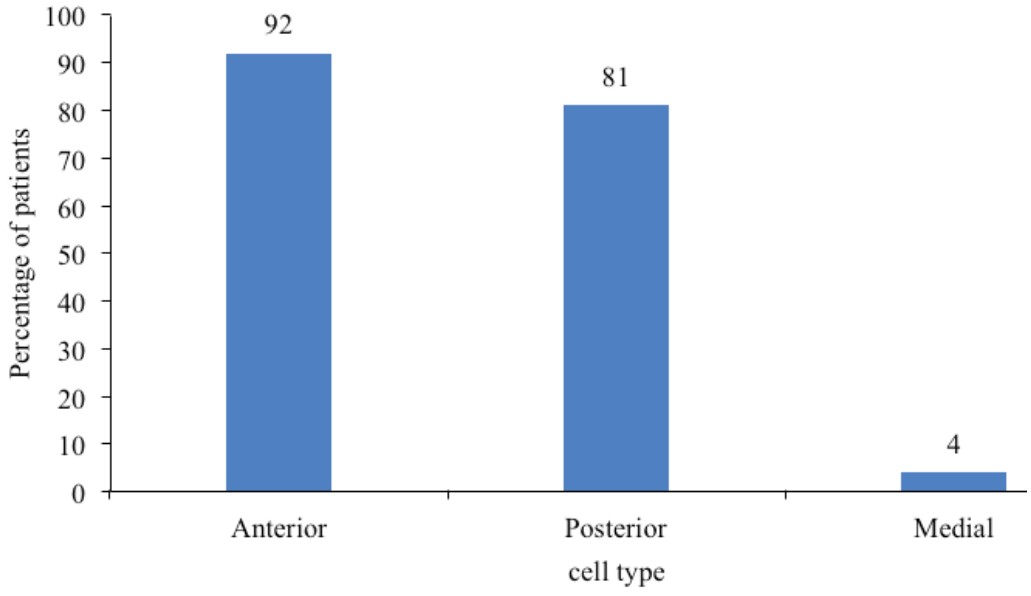


Figure 1: Class distribution of frontal cells

Table 2: Patterns of frontal recess cells

Cell type (n=200 sides)		Cell name (n=200 sides)	
Category	Frequency (%)	Category	Frequency (%)
Anterior cells	168 (84.0)	Agger Nasi Cell (ANC)	167 (83.5)
		Supra-Agger Cell (SAC)	32 (16.0)
		Supra-Agger Frontal Cell (SAFC)	2 (1.0)
Posterior cells	132 (66.0)	Supra-Bulla Cell (SBC)	126 (63.0)
		Supra-Bulla Frontal Cell (SBFC)	13 (6.5)
		Supra-Orbital Ethmoid Cell (SOEC)	2 (1.0)
Medial cells	4 (2.0)	Frontal Septal Cell (FSC)	4 (2.0)

Table 3: Laterality of frontal recess cells

Cell	Laterality (n=100 patients)		
	Bilateral	Unilateral	None
Agger Nasi Cell (ANC)	75 (75.0)	17 (17.0)	8 (8.0)
Supra-Agger Cell (SAC)	7 (7.0)	18 (18.0)	75 (75.0)
Supra-Agger Frontal Cell (SAFC)	0	2 (2.0)	98 (98.0)
Supra-Bulla Cell (SBC)	47 (47.0)	32 (32.0)	21 (21.0)
Supra-Bulla Frontal Cell (SBFC)	3 (3.0)	7 (7.0)	90 (90.0)
Supra-Orbital Ethmoid Cell (SOEC)	0	2 (2.0)	98 (98.0)
Frontal Septal Cell (FSC)	0	4 (4.0)	96 (96.0)

Patterns of Superior Attachment of Uncinate Process (SAUP) according to Landsberg and Friedman classification and drainage pattern

Out of the 200 sides examined, the most common attachment pattern was Type I (attachment to the lamina papyrecia) at 44% with the right having 40% and left 48%. This was followed by Type VI (attachment to the middle turbinate) at 22.5% with right having 25% and left 20%. Type III and IV had the least distribution, both at 5%. In terms of frontal sinus drainage, drainage into the middle meatus occurred in 55.5% while into the infundibulum was at 44.5%.

Table 4: Patterns of superior attachment of uncinate process and frontal sinus drainage pattern

Type (n=200 sides)		Frontal sinus drainage (n=200 sides)	
Category	Frequency (%)	Category	Frequency (%)
Type I	88 (44.0)	Into middle meatus	111 (55.5)
Type II	13 (6.5)		
Type III	10 (5.0)		
Type IV	10 (5.0)	Into the infundibulum	89 (44.5)
Type V	34 (17.0)		
Type VI	45 (22.5)		

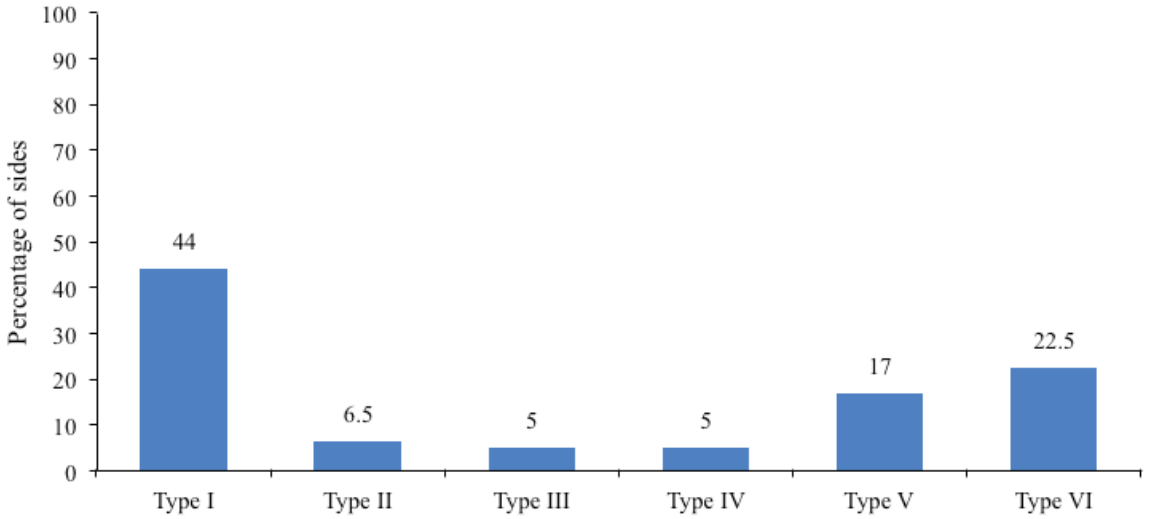


Figure 2: Pattern of distribution of SAUP

Table 5: Association between frontal recess cells and frontal sinus drainage pattern based on SAUP

Cells	Drainage		P-value
	Middle meatus	Infundibulum	
Anterior cells	96 (86.5)	72 (80.9)	0.284
Posterior cells	72 (64.9)	60 (67.4)	0.705
Medial cells	3 (2.7)	1 (1.1)	0.630
Agger Nasi Cell (ANC)	96 (86.5)	71 (79.8)	0.204
Supra-Agger Cell (SAC)	17 (15.3)	15 (16.9)	0.768
Supra-Agger Frontal Cell (SAFC)	2 (1.8)	0	0.504
Supra-Bulla Cell (SBC)	66 (59.5)	60 (67.4)	0.247
Supra-Bulla Frontal Cell (SBFC)	8 (7.2)	5 (5.6)	0.650
Supra-Orbital Ethmoid Cell (SOEC)	2 (1.8)	0	0.504
Frontal Septal Cell (FSC)	3 (2.7)	1 (1.1)	0.630

There was no statistically significant association between any of the frontal recess cells with the frontal outflow tract pattern based on SAUP.

DISCUSSION

The anatomy of the frontal recess affects the pattern of drainage of the frontal sinus. Frontal recess cells and the SAUP are key anatomical structures that contribute to the drainage pattern of frontal sinus, both of which vary in patterns of distribution depending on population under study. Several classifications have been used in describing the patterns of distribution of frontal recess cells as well as SAUP. In this study we evaluated the patterns using the IFAC criteria for frontal recess cells and Landsberge and Friedman for the SAUP.

In terms of the demographic characteristics, the mean age was 42 years with a range of 18-89 years and a male: female ratio of 13:7. The lower age limit of 18 years had been predetermined in the inclusion criteria since at that age the frontal sinus anatomy is expected to have fully developed. The average age and sex distribution is similar to other studies reviewed[1,3,5,8,14] and the range corrects for any age-related variability in anatomy if any. The mean age was comparable to the other studies which ranged from 44.9 to 51.9 years with the widest range being 18-79 years[1,3,5,8,14]. In studies reviewed, the male to female ratio varied with some studies having male preponderance, similar to this current study, and others female preponderance[1,3,5,8,14]. There was equal sex distribution (1:1) in one Egyptian study[1], this was a comparative study matched for age and

sex. The variant sex ratios may reflect the varied population from which the subjects were drawn from CT scanning. Some used reconstruction images from head, neck, maxillofacial and others were purely nose and paranasal sinus CT scans. This current study used paranasal sinus reconstruction images from head CT scans, nose and paranasal sinus and few high resolution temporal bone CT scans. The CT scanning protocols used in the setting was 1mm axial cuts with possibility of Multi Planar Reconstruction (MPR). This did not affect the ability to visualize cells or attachment type since recommended cuts is less than 2mm.

The most common pattern of distribution of frontal recess cells was the Aggar Nasi at 83.5% (200 sides) followed by the supra bulla cell at 63%. This is similar to the pattern seen by Choby *et al*[2], Sommer *et al*[15] and Sjorgen *et al*[16] in terms of the top two common frontal cell types. In comparison with other studies that have used the IFAC criteria, there have been variations in terms of proportions in pattern of distribution of frontal recess cells[2,15,16] as depicted in Table 8. The study samples ranged from 95 patients in Sjorgren *et al*[16] study to 249 patients in Sommer *et al*[15] study. In Sommer *et al*[15] study, patients had CRS complains hence able to draw a clinical correlation.

Table 6: Comparison of pattern of distribution of frontal recess cells

Author	Frontal recess cell pattern of distribution in %						
	ANC	SAC	SAFC	SBC	SBFC	SOEC	FCS
Sjorgen *et al* [15]	88.9	29.5	22.1	55.8	18.9	11.6	13.2
Choby *et al* [2]	96.5	30.0	20.0	72.0	5.5	28.5	30.0
Sommer *et al* [16]	95.2	49.0	24.9	88.8	26.5	9.2	27.7
Sargo *et al*	83.5	16.0	1.0	63.0	6.5	1.0	2.0

This current study concurs with patterns observed in all the above studies in terms of the most common and second most common cell type (ANC and SBC respectively) as well as a local study done by Maalim[18] that showed ANC to be the most common cell in his study population. Cells that pneumatize into the frontal sinus (SAC, SAFC, SBFC, SOEC and FCS) represented smaller percentages relative to other studies reviewed. This may be a unique pattern in the population under study and one may postulate that there may be lower incidence of isolated frontal sinus disease in this population due to theoretically reduced chance of narrowing of frontal sinus drainage pathway by such cells.

The superior attachment of the uncinate process also showed a wide variability in comparison with other studies. The most common pattern of attachment seen was Type I at 44% followed by Type VI at 22.5%. Other patterns and comparisons are as depicted in Table 9.

Table 7: Comparison of patterns of distribution of SAUP

Author	SAUP pattern of distribution in %					
	Type I	Type II	Type III	Type IV	Type V	Type VI
Landsberge & Friedman[11]	52	18.5	17.5	7.0	3.6	1.4
Turgut et al[20]	63.0		3.0	12.0	14.0	8.0
Kumar *et* al[21]	19.0	36.0	5.0	2.0	8.0	20.0
Sargo *et al*	44.0	6.5	5.0	5.0	17.0	22.5

Compared to patterns seen in Landsberg and Friedman[11] study whose population were patients with CRS, most common attachment type was to the lamina papyracea, Type I (52%), similar to our study. Other patterns were variably distributed with the least being Type VI, unlike in our study (Type VI was the second most common). Bilateral similarity of attachment was found in 93% of the scans[11]. In Turgut *et al*[19] study, combination of Type I and II attachment mode makes it difficult to compare this

group with other studies. In terms of the relationship between the frontal outflow tract and frontal sinusitis, Turgut *et al*[19] found a statistically significant relationship in the medially located outflow tract and frontal sinusitis. It was also a common form of outflow compared to lateral one, similar to our study where in terms of frontal sinus drainage, drainage into the middle meatus (medial group) occurred in 55.5% while into the infundibulum (lateral group) was at 44.5%. Our study was anatomical; we did not look into the incidence of frontal sinusitis versus pattern of drainage. Lastly, Kumar *et al*[21] study had a contrasting pattern to our study with Type II being the most common. In 11%, the superior end showed no attachment to surrounding structures[21]. One advantage of our study is that we were able to demonstrate SAUP in all the scans unlike Landsberge and Friedman[11], Kumar *et al*[21] and Turgut *et al*[19] who were unable to demonstrate SAUP in 40%, 11% and 26% of their population.

CONCLUSION

In our study population, the most common pattern of frontal recess cells was the Aggar Nasi Cell while Type I form of superior attachment of the uncinate process and medial drainage into infindubulum being predominant.

RECOMMENDATIONS

The surgeon should thoroughly study the patterns of both the frontal recess cells and superior attachment of the uncinate process on CT scans in order to determine the pattern of frontal sinus drainage pathway, plan appropriate surgery for the frontal recess and subsequently carry out complete clearance of cells during frontal sinus surgery. These patterns should also be part of imaging reporting protocol for paranasal sinus CT scans by the radiologist.

Funding

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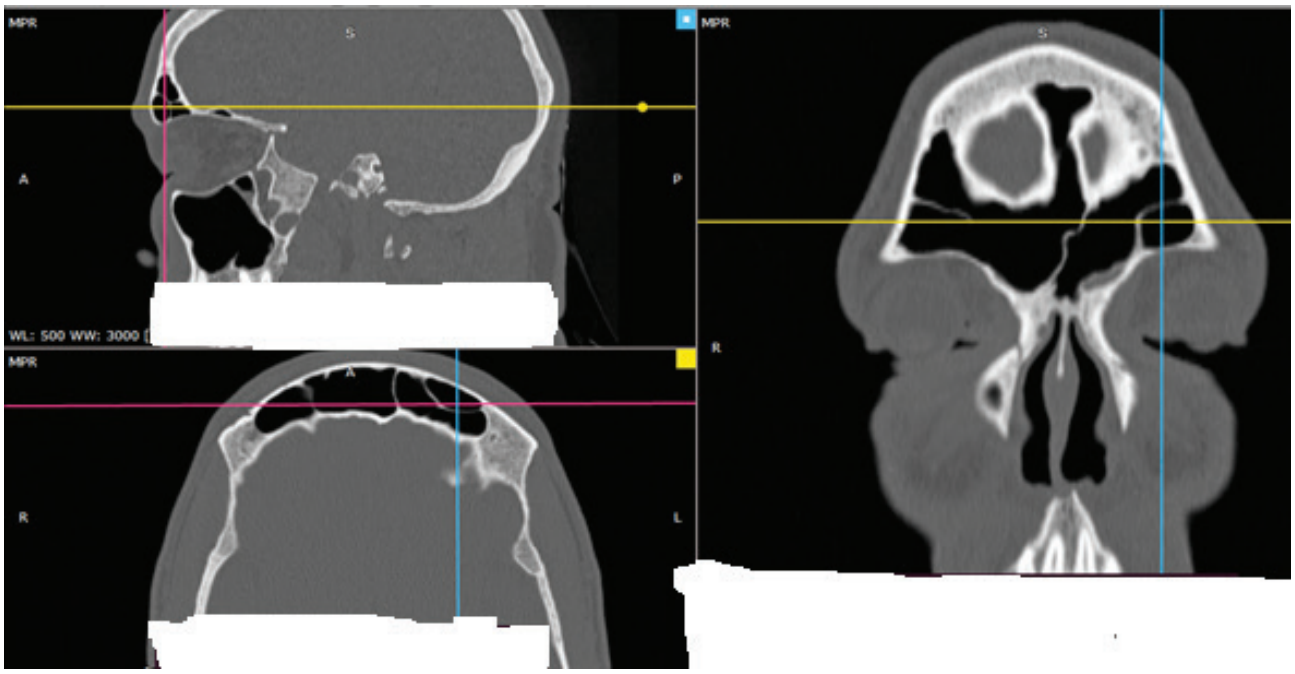
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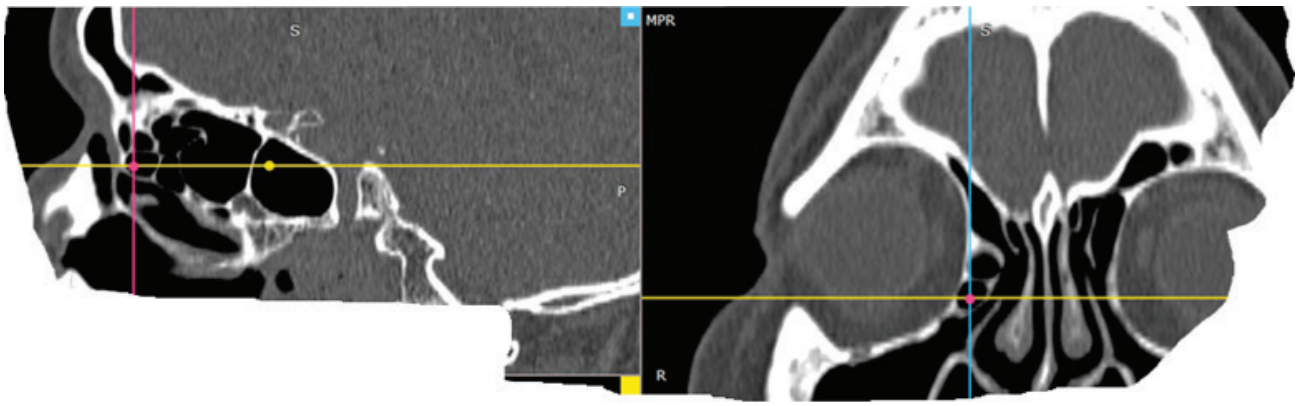
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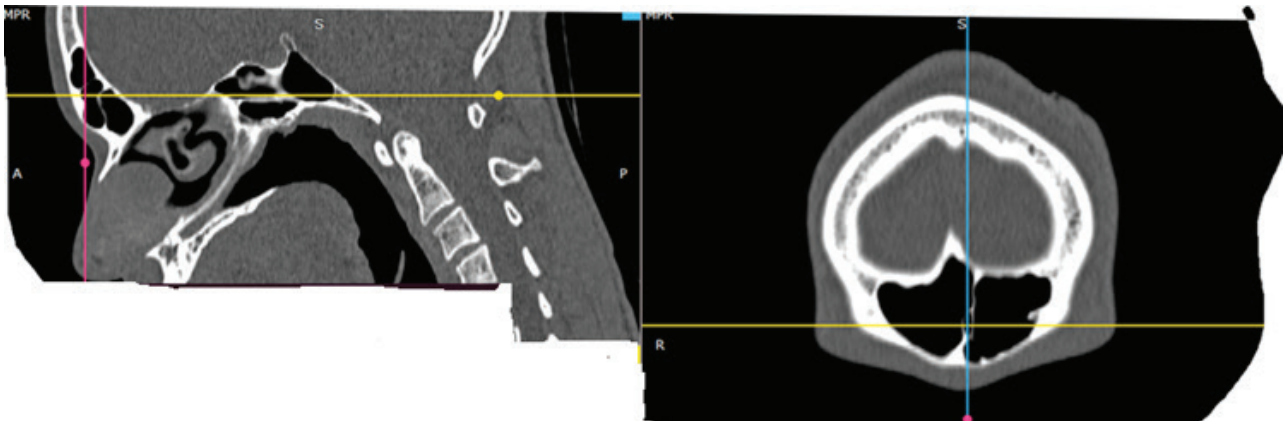
Appendix I: Sample images for frontal recess cells



SOEC (Image ID 18)



AN (Image ID 49)

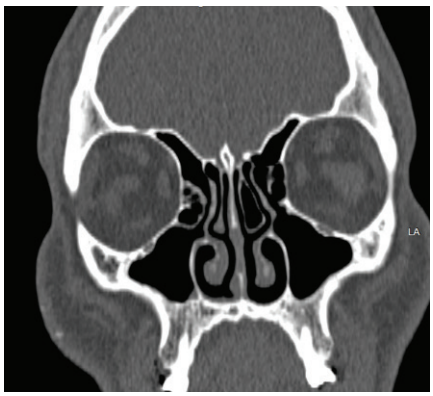


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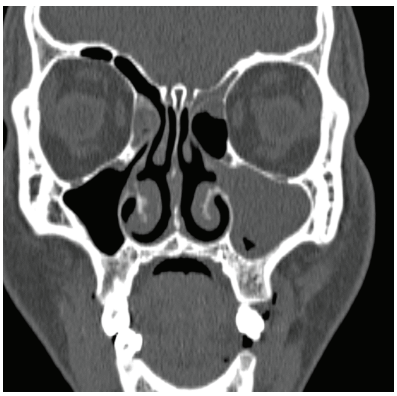


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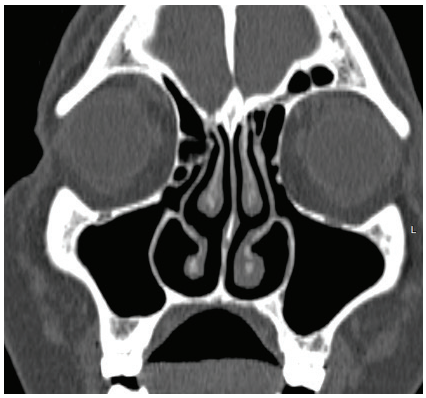
Appendix II: Sample images for types of superior attachment of uncinate process



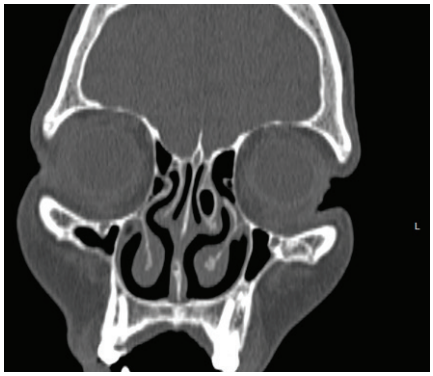
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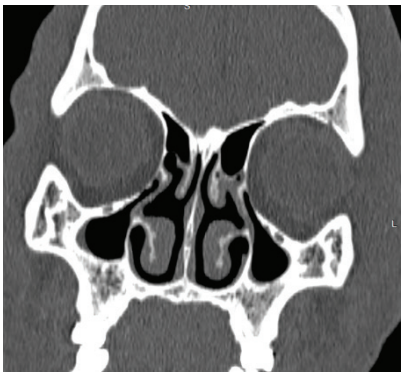
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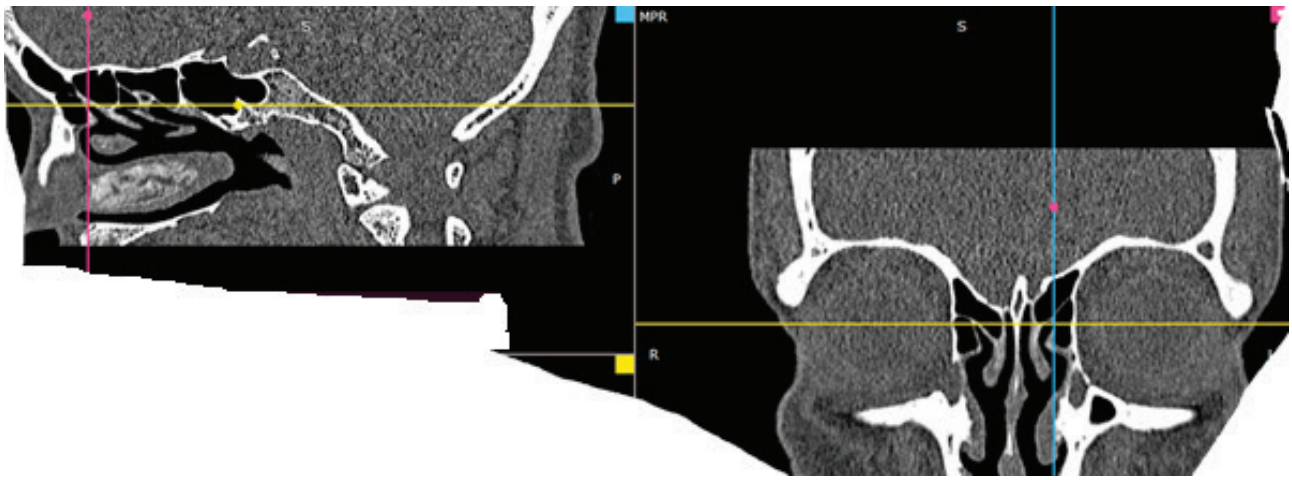
Type V (ID 87)



Type I (ID 85)



Type III (ID 53)



Type II (ID 99)

VITAMIN D LEVELS IN CHILDREN WITH OBSTRUCTIVE ADENOTONSILLAR DISEASE AT THE KENYATTA NATIONAL HOSPITAL, NAIROBI, KENYA

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ABSTRACT

Background: Adenotonsillar disease is a common problem for which children undergo surgery. Vitamin D plays an essential role in immunity, deficiency of which has been linked to disease in these lymphoid organs.

Objective: To determine vitamin D levels in patients with obstructive adenotonsillar disease scheduled for surgery.

Methodology: This was a case control study where eighty children under 12 years were recruited into the study comprising 40 cases and 40 controls. Demographic data including age, gender, weight, height and BMI were recorded. Venous blood was obtained for measurement of vitamin D levels. The process was repeated for the age and sex matched controls.

Results: There were 70% males and 30% females with a mean age of 4.4 ± 1.6 years. Vitamin D deficiency was found in 31.3% of the study population, 42.5% of the cases and 20% of the controls (OR=3.0 (95% CI: 1.1-8.0), p=0.05). Age (r= -0.39, p=0.01), weight (r= -0.34, p=0.03), height (r= -0.39, p=0.02) and BMI (r= -0.35, p=0.03) were inversely associated with vitamin D levels amongst the cases

Conclusion: Children with obstructive adenotonsillar disease were three times more likely to be vitamin D deficient with older age, increased height and obesity being risk factors.

Key words: Vitamin D, Adenotonsillar disease, Obstructive symptoms, Children

INTRODUCTION

Adenotonsillar hypertrophy is a common condition in children leading to upper airway obstruction which may also cause sleep disordered breathing[1]. Adenotonsillectomy is the most frequent elective procedure performed in Kenyan Ear, Nose and Throat/Head and Neck (ENT/HN) units, mainly for upper airway obstruction and recurrent tonsillitis[2,3]. Surgery is one of the important treatment modality, but can be associated with significant morbidity and very rarely mortality, hence, there may be significant advantage in searching for alternative medical therapeutic options that will reduce the burden of the disease.

Vitamin D is a fat-soluble vitamin which is required for an appropriate immune response, thus its deficiency may result in an increased risk of infections and inflammation of the upper and lower airway[4]. Deficiency of vitamin D can also increase the risk of other acute and chronic otolaryngologic disorders, such as asthma, chronic rhinosinusitis with nasal polyps, and recurrent otitis media[5]. Recurrent tonsillitis which can be due to biofilms can be prevented by having adequate levels of vitamin D[6].

There is a correlation between vitamin D deficiency and adenotonsillar disease and therefore, this study aimed to determine the vitamin D levels in children with obstructive adenotonsillar disease and compare them to those without the disease.

MATERIALS AND METHODS

The study was conducted in Kenyatta National Hospital (KNH), a tertiary hospital in Nairobi Kenya between March 2021 and March 2022 after ethical approval was obtained. The study involved 40 cases who were children under 12 years with a diagnosis of obstructive adenotonsillar disease scheduled for surgery and 40 controls who were children under 12 years attending well-baby and paediatric surgical unit without symptoms of obstructive adenotonsillar disease. They were age and sex matched with cases. Children on systemic steroids, anticonvulsants, antiretrovirals, antifungals (ketoconazole) and vitamin D supplementation were excluded from the case group. Similarly, children who had adenotonsillectomy and those on systemic steroids and vitamin D supplementation were excluded from the control group. Convenient sampling was used to recruit participants.

Informed consent was sought for all study participants, and each subject had demographic data including age, sex, weight, height and BMI captured in the data collection sheet by the principal investigator. Using sterile venipuncture technique, two-milliliters of venous blood was drawn using a disposable syringe. Blood was collected and put in a plain vacutainer tube (red topped) that was labelled, and taken to the instituition's laboratory for assessment of vitamin D.

Assessment of vitamin D

Serum vitamin D was determined by LIASON R 25-OH vitamin D Assay technique, which adopts a "Flash" chemiluminescence technology (CLIA) with a pragmatic microparticle solid phase (MP). This method is rapid, accurate and precise. The National Committee for Clinical Laboratory Standards (NCCLS) protocols has validated this method[7]. Additionally, it's comparable to the gold standard Liquid Chromatography Isotope Dilution Tandem Mass Spectrometry (LC-IDM/MS)[8] and well correlated with radioimmunoassay technique[9]. The normal reference ranges were derived from the equipment manufacturer (30-80 ng/ml).

RESULTS

The study's major goal was to compare vitamin D levels in children who had or didn't have obstructive adenotonsillar illness. Between the two groups, the relationship between age, gender, weight, height, BMI, and vitamin D was also determined.

Social-demographics and anthropometric characteristics of study population

This study involved a total of 80 participants. Out of these, 40 had obstructive symptoms of adenotonsillar disease while 40 didn't have any obstructive symptoms. Those with obstructive symptoms, 28 were males and 12 were females and they were matched for age and sex with the control group giving a total sex distribution of 56 (70%) for males and 24 (30%) for females with a male: female ratio of 2.3:1 (Figure 1)..

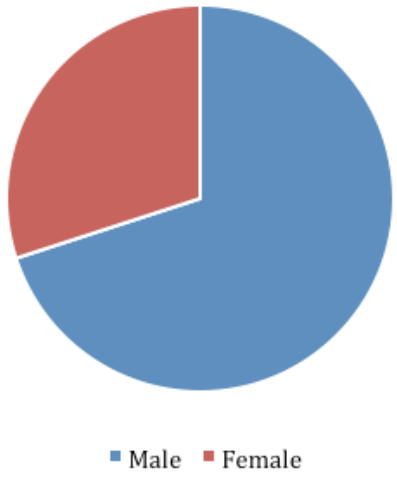


Figure 1: Sex distribution

The mean age for both groups was 4.4 ± 1.6 years. The average weight of the study group was slightly lower at 18.3 ± 4.5kg and that of the control group was 19.4 ± 4.6kg (p=0.26). Similarly, the average height of the study group was lower at 107.7cm ± 9.6cm while that of the control group was 109.7cm ± 10.2cm (p=0.37). The average BMI of the study group was higher at 16.0 ± 2.0 while that of the control group was 15.5 ± 1.5 (p=0.35).

Vitamin D levels in cases and controls

Vitamin D deficiency was defined as a serum level of vitamin D of <30ng/ml (75nmol/l). Both groups had normal average vitamin D levels, however, the study group was lower at 32.8 ± 13ng/ml and the control group at 35.6 ± 8.6ng/ml (p=0.26) (Figure 1). The lowest vitamin D level in the cases was 7.01ng/ml and 17.61ng/ml in the control group. Seventeen out of 40 (42.5%) cases had vitamin D deficiency while 8 out of 40 controls (20%) were noted to be vitamin D deficient (p=0.05, odd ratio=3.0 (95% CI:1.1-8.0)). Vitamin D deficiency was found in 25 (31.3%) of the total population (Figure 2).

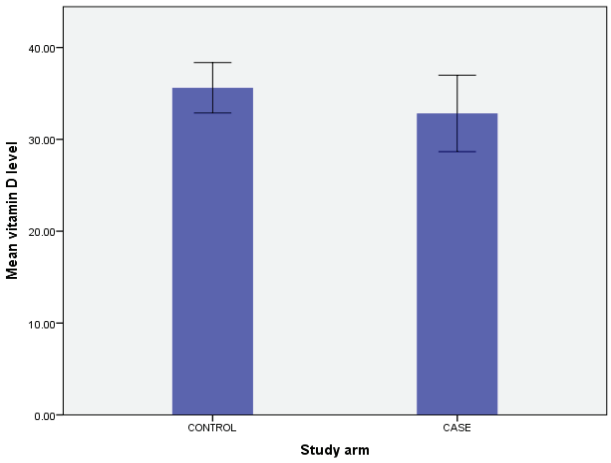


Figure 2: Mean vitamin D levels

Correlation between age, gender, weight, height and BMI and vitamin D for cases

Vitamin D deficiency was more prevalent amongst females than males (50% vs 39.3%, p=0.73), and more prevalent in children greater than 5 years (60% vs 36.7%, p=0.27) (Table 1).

Table 1: Correlation between age, gender and vitamin D for cases (Chi-squared test)

Variable		Normal vit D levels	Vitamin D deficiency	P-value
Gender	Female	6 (50%)	6 (50%)	0.73
	Male	17 (60.7%)	11 (39.3%)	
Age	≤5	19 (63.3%)	11 (36.7%)	0.27
	>5	4 (40%)	6 (60%)	

We used Spearman's rank correlation to explore correlations between the socio-demographic variables and vitamin D. Age (r= -0.39, p=0.01), weight (r= -0.34, p=0.03)), height (r= -0.39, p=0.02) and BMI (r= -0.35, p=0.03) were inversely associated with vitamin D levels (Table 2).

Table 2: Correlation by spearman's rank correlation for cases

Variable	Spearman's correlation coefficient	P-value
Age	-0.39	0.01
Weight	-0.34	0.03
Height	-0.39	0.02
BMI	-0.35	0.03

Correlation between age, gender, weight, height and BMI and vitamin D for controls

Vitamin D deficiency was more prevalent amongst the males than females (21.4% vs 16.7%, p=1.00), and more prevalent in children less than and equal to 5 years (26.2% vs 0, p=0.17). We used Spearman's rank correlation to explore correlations between socio-demographic variables and vitamin D. Age (r= 0.52, p=0.001), weight (r=0.51, p=0.001), height (r=0.41, p=0.008) and BMI (r=0.25, p=0.10) were positively associated with vitamin D levels.

Correlation between age, gender, weight, height and BMI and vitamin D for the total population

Vitamin D deficiency was more prevalent amongst females than males (33.3% vs 30.4%, p=0.80), and more prevalent in children less than and equal to 5 years (31.7% vs 30%, p=1.00). We used Spearman's rank correlation to explore correlations between socio-demographic variables and vitamin D. Age (r=0.003, p=0.88), weight (r=0.03, p=0.77), height (r=0.00, p=1.00) and BMI (r=0.046, p=0.68) exhibited positive relationships with vitamin D.

DISCUSSION

Although our country benefits from ample sunlight, higher levels of melanin in the dark-skinned population act as a natural sunscreen, necessitating more sunlight exposure for children[10]. In their study, Kagotho *et al*[10] found that black healthy people in Nairobi who were exposed to more than three hours of sunshine were less likely to be vitamin D deficient than those who were exposed to less than one hour, although the difference was not statistically significant. Genetic polymorphisms lead to lower levels vitamin D binding protein in black populations. This being the principal vitamin D carrier protein consequently leads to lower vitamin D levels[11].

This study involved 80 children, with 70% of them being male. Okerosi *et al* (unpublished data) reported a 65% male predominance in children with obstructive sleep disordered breathing undergoing adenoidectomy and or tonsillectomy at KNH. The average age of the subjects was 4.4 years. Because the influence of adenoid/tonsil size decreases as a child develops, we discovered fewer older children with obstructive adenotonsillar disease.

Vitamin D deficiency was found in 31.3% of the participants in the study. Shin *et al*[5] reported a higher prevalence of 52.3%, which could be attributed to Korea's higher latitude and thus colder temperatures than Kenya.

Although the means of vitamin D did not differ significantly between the two groups in our study, the study group had a lower vitamin D mean than the control group, and the number of participants with low blood vitamin D was higher among the cases (42.5% vs 20%, p=0.05). Vitamin D plays a vital role in immune regulation and deficiency may lead to hypertrophy of the adenoids/tonsils. Reid *et al* [12] concluded that lower vitamin D levels were significantly associated with larger tonsil size. Shin *et al*[5] showed that 91.3% of children with vitamin D deficiency had adenoid and/or tonsillar hypertrophy. This high prevalence could be because of using tonsil grades 3 and 4 and adenoid nasopharyngeal ratio ≥ 0.8 to define hypertrophy while we only used obstructive symptoms. Our findings are in keeping with a study done by Aydin *et al*[13] in Turkey which also didn't show a statistically significant difference between the mean vitamin D levels in the two groups but a higher prevalence of vitamin D deficiency was seen in the study group (18% vs 0, p<0.001). However, their study group comprised of children with recurrent tonsillitis. Another pilot study done in the US didn't show any difference in the levels of vitamin D in children undergoing adenotonsillectomies and controls. Again, the study group comprised of children with obstruction and recurrent infections and the season in which blood was collected was not specified. Differences in latitude, skin pigmentation, and seasons could be responsible for the conflicting findings.

Vitamin D is a fat-soluble vitamin which deposits in body fat, hence, children who are overweight or obese tend to have vitamin D deficiency. We found that the study group had a higher BMI when compared to the control group though not statistically significant (16 vs 15.5, p=0.35). However, BMI was inversely correlated with vitamin D (Spearman's rank= -0.35, p=0.03) in children with obstructive adenotonsillar disease but not in the control group or the total population. Reid *et al*[12] and Shin *et al*[5] were also able to demonstrate an inverse relationship between BMI and serum vitamin D levels. Similarly, even age, weight and height showed an inverse relationship with vitamin D in the cases but not in the controls or the total population.

Deficiency of vitamin D has been associated with the development of lower respiratory tract infections in children under the age of five[14, 15]. In our study, there was no significant difference in vitamin D deficiency in children who were less than 5 years when compared to children more than 5 years in cases, controls or the total population. This may be because of the study having fewer children who were older than 5 years. However, we found a statistically significant inverse relationship between age and vitamin D levels in the cases which could be due to reduced levels of 7-dehydrocholesterol in the skin with older age.

Our study found no association between gender and vitamin D deficiency in cases, controls, or the study population, however, vitamin D deficiency was commoner in females with obstructive adenotonsillar illness. This may be due to women having slightly increased body fat and, as a result, lower vitamin D levels. In addition, Aydin *et al*[11] found no correlation between gender and vitamin D levels.

Conclusion

Almost half of the children with obstructive adenotonsillar disease were vitamin D deficient. This study showed that children with obstructive adenotonsillar disease were three times more likely to have vitamin D deficiency compared to those without. Age, weight, height and BMI were inversely associated with vitamin D levels in the study group.

Recommendations

We recommend that children having obstructive adenotonsillar disease should be assessed for vitamin D deficiency for prompt diagnosis and intervention which will also assist in protecting the child from further respiratory tract infections. In such patients, BMI should be monitored closely and corrected if abnormal. Further studies should be carried out in multiple centers with larger sample sizes to better define the prevalence of vitamin D deficiency and associated risk factors. We also recommend that such children should be put on vitamin D supplementation and observed for upper respiratory tract infections.

Limitations of the study

- The study had a small sample size, to allow more detailed generalizations to be made.
- Although we only used black children, the different skin types amongst them was not taken into consideration.

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SHORT TERM OUTCOMES OF LAPAROSCOPIC NISSEN FUNDOPLICATION FOR ASTHMA RELATED TO GASTROESOPHAGEAL REFLUX DISEASE IN KENYA

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ABSTRACT

Background: Gastroesophageal Reflux Disease (GERD) can contribute to asthma symptoms through vagal nerve mediated reflexes or refluxate microaspiration.

Objective: This study aims to determine the clinical impact of Laparoscopic Nissen's Fundoplication (LNF) on asthma medication use, and GERD symptoms among asthmatics with Proton Pump Inhibitors (PPI's) responsive but dependent GERD.

Methods: From a prospectively maintained database of 134 adult patients with confirmed diagnosis of GERD, and who underwent LNF between April 2014 and April 2018, fifteen were identified with extra-oesophageal symptoms related to asthma and requiring continuous or intermittent use of asthma medication. Typical GERD symptoms were present in all patients and were treated with maximum dose PPI's for at least 12 weeks to determine responsivenesss and dependence (i.e., refractory). Symptom and medication use assessments were performed prior to anti-reflux surgery and postoperatively, over 2-weeks, 1, 3 and 6 months.

Results: Fifteen patients (4 males and 11 females) were identified to have asthma, with a mean age of 38 ± 12.33 (SD) years (range 21–65) and BMI of 27.8 ± 4.9 (range: 19.5–38.2) kg/m^2 respectively. All had typical symptoms of GERD, Hill's grade C/D hiatus hernia and variable degrees of oesophagitis. All patients reported improvement in their typical and atypical GERD symptoms 6 months post-surgery and a significant decrease asthma symptoms controller therapy, including complete resolution postoperatively. There were no surgical complications and the average length of post-operative hospitalization was 2 ± 1 days.

Conclusion: Adults with asthma and GERD responsive to, but dependent on medical management who undergo LNF, show improvement in their GERD and asthma based on reduction in symptoms and medication use.

Key words: Asthma, Gastroesophageal reflux disease, Laparoscopic Nissen fundoplication

INTRODUCTION

Gastroesophageal Reflux Disease (GERD) is defined as the pathologic reflux of gastric and duodenal contents causing troublesome symptoms, with or without tissue damage and/or complications[1,2]. It is one of the commonest digestive disorders afflicting 20%-30% of the population[3-5], and its prevalence seems to be increasing globally[1]. Symptoms are considered to be troublesome if they adversely affect the individual's well-being[3].

Patients with GERD can present with oesophageal (heartburn and regurgitation) and extraoesophageal (chronic cough, asthma, laryngitis, and dental erosions) manifestations, which adversely affect the well-being and quality of life of the patients significantly[6-8]. Asthma is considered the main extra-oesophageal manifestation of GERD. Two mechanisms have been proposed to explain extraoesophageal GERD syndromes. The first is direct reflux to the target organ causing irritation[6]. The second is an oesophagus-tracheobronchial reflex that is triggered by chemical stimulation of the distal oesophageal mucosa and mediated by the vagus nerve, based on the common embryologic origin of the oesophagus and the tracheobronchial tree[2,9]. GERD should therefore be considered as a potential co-factor in patients with asthma, chronic cough, or laryngitis[10,11]. Of note, some of the drugs used for asthma control such as theophylline and beta-adrenergic agonists may exacerbate the reflux because they relax the smooth muscles of the

oesophagus and stomach causing a delay in gastric emptying, which creates a pro-reflux effect[12,13].

A trial of Proton Pump Inhibitors (PPIs) is recommended to treat extraoesophageal symptoms in patients who also have typical symptoms of GERD, while reflux monitoring should be considered before such a trial in patients with extraoesophageal symptoms who lack typical symptoms of GERD. Non-responders to a PPI trial should be considered for further diagnostic testing[11] dysphagia, recurrence of symptoms and gas-related symptoms are experienced in 10% to 20% of patients postoperatively. To date, the adequate follow-up of patients undergoing laparoscopic fundoplication is not well established. In addition, the outcomes of patients undergoing antireflux surgery for Barrett' oesophagus (BE and might benefit from surgical anti-reflux therapy.

Whereas laparoscopic antireflux surgery has been shown to significantly improve typical GERD symptoms and reduce the need for medications[14], its impact on atypical symptoms such as asthma is not yet fully established. This is particularly important given the recent growing concern over adverse effects associated with long-term PPI therapy[15-17].

This study aims to analyze the effectiveness of laparoscopic Nissen's fundoplication in the treatment of GERD-related asthma.

MATERIALS AND METHODS

Study population

From a prospectively maintained database of 134 patients aged over 18 years with confirmed diagnosis of gastroesophageal reflux disease and who underwent laparoscopic fundoplication between April 2014 and April 2018, 15 (11.2%) patients with extraoesophageal symptoms related to asthma (a history of wheezing, coughing, or dyspnoea attacks), and requiring continuous or intermittent use of medication were identified. The indication for anti-reflux surgery was persistent symptoms of GERD and oesophagitis despite at least three months of treatment with maximum dose PPI's with or without prokinetics and antacids. It is significantly noteworthy that, all were responsive but dependent on antisecretory medication for relief of the typical and atypical symptoms of GERD.

Surgical technique

All patients underwent Laparoscopic Nissen's Fundoplication (LNF). In all patients, the fundus of the stomach was fully mobilized, the short gastric vessels were not routinely divided except when it was necessary for complete fundal mobilization. The occasional aberrant left hepatic artery arising from left gastric and coursing across the pars flaccida of the gastrohepatic ligament was well secured when present. Crura hiatus repair was performed behind the oesophagus with interrupted non-absorbable sutures. A loose, short and floppy posterior 360 degrees fundoplication was performed in all of them.

Patient data

Data from the patients was obtained over a 4-week period prior to anti-reflux surgery and postoperatively, over 2-weeks, 1, 3, 6 and 12 months and annually thereafter. The parameters considered were the intensity of the gastroesophageal symptoms according to the use and dosage of the specific medication, the number of asthma crisis, antiasthma medications used and the degree of oesophagitis. The typical symptoms of GERD (heartburn and regurgitation) were recorded daily on a scale of 0–3. The asthma crisis was classified as intermittent (none or <2/week), mild (3-4/week), moderate (daily) and severe (continuous). The daily use of inhaled rescue bronchodilators and any change in regular asthma medication were also recorded. The Los Angeles degree of oesophagitis was obtained by upper endoscopy performed preoperatively and on 6^{th}, 12^{th} months and annually thereafter postoperatively. For analytical purposes, data was compared for T1 (pre-operative), T2 (6 months post-operative).

Study outcomes

The primary outcome was the effect of antireflux on GERD-associated asthma symptoms and anti-asthmatic medications use, while the secondary outcome was the effect of antireflux surgery on typical GERD symptoms and proton pump inhibitor use.

Statistical analysis

Data analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 25 (IBM, Chicago). Variables analysed in this study include the proportion of patients with heartburn, regurgitation, dysphagia and various categories of asthma crises; the degree of oesophagitis and the proportion of patients using proton pump inhibitor, inhaled beta agonist, anticholinergics, inhaled corticosteroids, xanthine,

oral beta-agonist and inhaled corticosteroids. Continuous data are presented as mean (range) while categorical data are presented as number (percentage). Before (preoperative, T1) and after (6 months, T2) comparison was conducted using the McNemar's test for paired nominal data. A $p<0.05$ was considered significant at a 95% confidence interval (CI). The results are presented in tables.

RESULTS

Baseline patient characteristics

The mean age of the included patients was 38 ± 12.33 years (range: 21-65), while the mean BMI was 27.8± 4.9 kg/m^2 (range: 19.5 – 38.2). Majority of them were male (73%). Ten patients (66.67%) had reflux disease for more than five years. Typical symptoms included heartburn in 14 (93.33%), regurgitation in 12 (80%) and mild dysphagia in 7 (46.67%). Nine patients (60%) had asthma crisis for over five years. Five (33.33%) had less than two asthma crisis per week, 6 (40%) had 3-4 per week and the other 4 (26.67%) had continuing crises while not on rescue medication. All patients were on proton pump inhibitors, antacids and inhaled beta agonists. Other patients were also on anticholinergics (12, 52.2%), oral theophylline (8, 53.3%), inhaled corticosteroids (5, 33.3%) and oral beta-2 agonist (3, 20%). All patients had a hiatal hernia (Hill's Grade C/D) and endoscopic oesophagitis Los Angeles class A in 2 (13.33%), B in 7 (46.67%), C in 5 (33.33%) and D in 1 (6.67%) (Table 1). There were no surgical complications and the average length of post-operative hospitalization was 2± 1 days.

Table 1: Demographic data and current medication in patients with asthma (n=15) prior to anti-reflux surgery

Patients with asthma		
Male/female		11/4
Age, years (range)		38 (21–65)
Medications	Inhaled bronchodilators	15
	Inhaled corticosteroids	5
	Oral b_2 agonist	3
	Oral theophylline	8
	Proton pump inhibitors & antacids	15
	Prokinetics	6
Duration of respiratory symptoms, years (range)		5 (1-23)
Degree of oesophagitis	Class A	2
	Class B	7
	Class C	5
	Class D	1

Effect of antireflux on GERD-associated asthma symptoms and anti-asthmatic medications use

Comparing T1 (pre-operative) and T2 (6 months post-operation), there was a significant difference between the patients with intermittent (33.33% versus 6.67%), mild (40% versus 0%) and continuous asthma crises (26.67% versus 6.67%). There was significant difference between T1 and T2 in the use inhaled beta agonists and oral theophylline. Although the use of anticholinergics, inhaled corticosteroids and oral beta-agonist reduced between T1 and T2, these reductions were not statistically significant (Table 2)

Table 2: Comparative analysis of medication related to asthma symptoms between times T1 (pre-operative) and T2 (6 months post-operation)

Medication	T1 (pre-op)	T2 (6 months post-op)	p
Inhaled beta agonist	15 (100%)	1 (6.67%)	<0.001*
Anticholinergic	12 (80%)	7 (30.43%)	0.063
Inhaled corticosteroids	5 (33.33%)	2 (13.33%)	0.500
Xanthine	8 (53.33%)	0 (0.00%)	0.008*
Oral beta agonist	3 (20.00%)	0 (0.00%)	0.250

Effect of antireflux surgery on typical GERD symptoms and proton pump inhibitor use

The comparative analysis between the pre-operative evaluation (T1) and six months (T2) after surgery showed a significant reduction in symptoms of heartburn, regurgitation, and the use of Proton Pump Inhibitors (PPIs). On the other hand, the symptom of dysphagia showed a non-significant reduction at 6 months (Table 3). A repeat oesophagogastroduodenoscopy (OGD) performed at six months of surgery (T2) as per Visick protocol showed a significant improvement (p=0.044) in the degree of the oesophagitis, using the Los Angeles Classification (Table 4).

Table 3: Comparison of typical GERD symptomatology and use of PPI's at T1 (pre-operative) and T2 (6 months post-op)

Variables	T1	T2	p
Heartburn	14 (93.33%)	2 (13.33%)	p<0.001
Reflux	12 (80.00%)	1 (6.67%)	p=0.001
Dysphagia	7 (46.67%)	3 (20%)	p=0.125
Use of proton pump inhibitor	15 (100)	2 (13.33%)	p<0.001

Table 4: Comparison of the degree of oesophagitis between times T1 (pre-operative) and T2 (6 months post-op)

Degree of oesophagitis	T1	T2*
A	2 (13.33%)	2 (13.33%)
B	7 (46.67%)	1 (6.67%)
C	5 (33.33%)	1 (6.67%)
D	1 (6.67%)	0 (0%)

*p= 0.044

DISCUSSION

The association between Gastro-Esophageal Reflux Disease (GERD) and asthma has a remarkably long history. One of the earliest descriptions of the possible association between the two entities was by Sir William Osler in 1892 in his book *"The Principles and Practice of Medicine"*[18]. He noted and remarked that "overloading" the stomach could be a precipitant of paroxysms of asthmatic attacks[18]. Borey *et al*[19] in 1934 noted that overeating shortly before bedtime precipitated asthma in some patients[19,20]. In 1946, Mendelson[21] noted an acute asthma-like attack, characterized by dyspnoea, cough, wheeze, cyanosis, and tachypnoea among 40 patients who had aspirated gastric contents during general anaesthesia. In their analysis of 1,148 patients operated on for GERD/hiatal hernia between 1946 and 1965, Urschel and Paulson[22] reported the presence of asthma/wheezing in approximately 16% of the patients. Several other

observations of historical nature[21,23], as well as animal studies, have affirmed the concurrence of the two diseases[24,25]. Asthma was eventually recognized and classified by the 2007 Montreal consensus as one of the extraoesophageal syndromes of GERD with an established association[1].

The diagnosis of GERD-related asthma is usually uncomplicated in patients with typical GERD symptoms, as in our case series. It may however be challenging in patients with "silent GERD", or atypical symptoms[6,23]. The diagnostic difficulties are further compounded by the non-specific nature of their symptoms, and the lack of standard diagnostic tests[26]. Nonetheless, a diagnosis of GERD-related asthma may be inferred in patients with a favorable response of asthma to antisecretory therapy[23]. Similarly, patients with severe exacerbations / poorly controlled asthma despite optimal use of anti-asthma medications should be evaluated for GERD, as recommended by the National Heart, Lung and Blood (NHLB) Institute recommendations[6,27]. Supportive evidence of GERD-related asthma may be obtained through endoscopy (to demonstrate the presence of erosive oesophagitis) and oesophageal manometry (to demonstrate a hypotensive lower oesophageal sphincter)[23]. Ambulatory oesophageal pH monitoring may allow for correlations between oesophageal acidification and asthmatic symptoms[6,23]. The role of pulmonary function tests in the diagnosis of GERD-related asthma has yet to be established.

The treatment of GERD-related asthma is not yet standardized. Initial treatment includes a combination of lifestyle modifications (weight reduction, avoidance of heavy meals, eating at least 3-4 hours before sleeping, and elevation of the head of the bed), medical anti-reflux therapy, and anti-asthma medications. Several Randomized Clinical Trials (RCTs) have investigated the role of antisecretory therapy with Proton Pump Inhibitors (PPIs) in the treatment of GERD-related asthma, albeit with contradictory findings. For instance, Kiljander *et al*[28] reported significant improvement in the morning Peak Expiratory Flow rate (PEF), Forced Expiratory Volume in 1 second (FEV1), and quality of life, with no significant change in the evening PEF, asthma exacerbation, and use of rescue bronchodilator therapies in patients taking 40mg of esomeprazole compared to the placebo group. Sharma *et al*[29] on the other hand noted reduction of asthma symptoms, improvement of Pulmonary Function Tests (PEF, FEV1 and Forced Vital Capacity (FVC)), and reduced need of rescue therapy in patients receiving iansoprazole. Several other RCTs have reported inconsistent findings[30,31], which could be attributed to varying severity of asthma and GERD in the included patients.

A significant proportion of patients may fail to achieve satisfactory responses despite maximum doses of antisecretory therapy[6]. Such patients may benefit from Mmultichannel Intraluminal Impedance and pH-meter (MII-pH), to rule out asthma due to other causes[6]. Patients with a positive oesophageal pH test might benefit from surgical antireflux therapy. This is particularly important given the recent growing concern over adverse effects associated with long-term PPI therapy[15-17].

The decision to proceed with surgery in this group of respiratory compromised patients was often a risky one due to the morbidity and mortality associated with open thoracic or abdominal antireflux procedures[32]. Historically, even for typical GERD symptoms, antireflux surgery has been reserved for severe oesophagitis or stricture or those refractory to medical therapy because of the relatively high morbidity and mortality associated with open antireflux procedures. The demonstration of decreased morbidity, shorter convalescence, and periods of disability with laparoscopy, coupled with the demonstration of the success of these procedures, have greatly decreased the threshold for referral to surgery for these patients with GERD. This has shifted the balance such that patients with less severe diseases are now considered surgical candidates. It has been emphasized that these patients with less disease are precisely the best candidates for laparoscopic antireflux procedures as far as typical symptoms are concerned[33]. Recent use of laparoscopic techniques in antireflux surgery may provide these patients with a major reduction in postoperative morbidity despite their poor respiratory status[32].

To date, only one RCT has compared the efficacy of medical versus surgical antireflux therapy for the treatment of GERD-related asthma. Sontag *et al*[18] randomized 62 patients with GERD-related asthma into the medical arm (22 patients receiving ranitidine, 150mg three times a day) and surgical arm (16 patients, undergoing Nissen fundoplication). At the end of the 2-year follow-up, patients in the surgical group reported improvement/cure rates of 74.9% compared to 9.1% in the medical group. No significant differences were however seen in the PEF between the two groups. Of note, no study has compared the effects of PPIs, which have largely replaced H2-receptor antagonists, to that of surgical antireflux therapy.

In the current study, we observed a significant reduction in the asthma crises and medication use

(PPIs, inhaled beta-2 agonist, xanthine) at 6 months post-Nissen fundoplication compared to baseline (pre-operative period). Despite our small sample size, our findings are largely consistent with that of previous retrospective and prospective reports[34-36]. For instance, Rothenberg and Cowles[34] in their study of 235 patients with severe steroid-dependent asthma undergoing LNF noted a significant improvement of respiratory symptoms in 91% of the cases, while 80% were successfully weaned off steroids in the first two post-op months and another 24% had significant improvements in their FEV1[34]. In a similar study, Patel *et al*[36] reported reduced post-operative steroid requirement among asthmatic patients with PPI-resistant GERD undergoing LNF, with approximately 57% being successfully weaned-off steroids. In a multicentre study of 24 patients with severe asthma and treatment-resistant GERD, Esposito *et al*[37] reported resolution of asthma symptoms in 91.6% of patients, with concurrent improvement in their quality of life. Rakita *et al*[38] analyzed 322 patients with extraoesophageal GERD including asthma and chronic cough undergoing LNF, and reported a significant improvement in their symptom control and reduction in the need for controller medications post-LNF. In a systematic review of over 13 studies assessing the effects of LNF on GERD-associated asthma, Sidwa *et al*[26] concluded that anti-reflux surgery might be effective in treating extra-oesophageal GERD syndromes, including asthma. They however noted that the current body of literature is insufficient with regards to the identification of patients likely to benefit from surgical intervention, the time to, and duration of the benefits as well as the most appropriate surgical technique[26].

We also noted that LNF resulted in improvement of grades of oesophagitis as assessed by oesophagoscopy, and this is consistent with previous studies[39,40]. For instance, Luostarinen *et al*[41] reported healing of oesophagitis in approximately 79% of cases as assessed by endoscopy. In a similar study, Battle *et al*[42] reported resolution of oesophagitis in 96% of patients with GERD after Nissen fusndoplication. The resolution of oesophagitis as assessed by endoscopy has been demonstrated to correlate with post-fundoplication histological changes of oesophageal mucosa[41], and can be sustained for up to 15 to 20 years[40,43], provided the integrity of the fundal wrap is maintained[41].

Our study was limited by several factors. First, we could not assess changes in the pulmonary functions following anti-reflux surgery since we did not perform spirometry. Secondly, the patients included had GERD and asthma that was responsive but dependent on medical therapy. Our findings may therefore not be extrapolatable to those with a disease that is non-responsive to medical therapy.

CONCLUSION

Adults with asthma and GERD responsive but dependent on medical management who undergo laparoscopic Nissen's fundoplication surgery, show improvement in their GERD and asthma based on reduction in symptoms and medication use

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SURGICAL AUDIT OF TRACHEOSTOMIES PERFORMED IN KENYATTA UNIVERSITY TEACHING, REFERRAL AND RESEARCH HOSPITAL (KUTRRH) 2023

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ABSTRACT

Background: Tracheostomy is a surgical procedure involving creating an opening in the neck directly into the trachea. The primary indications of tracheostomy include; long term mechanical ventilation, weaning failure, upper airway obstruction, and management of copious secretions.

Objectives: To evaluate the demographics of patients undergoing tracheostomy, assess preoperative evaluations, concurrent procedures and determine the 7-day postoperative outcomes.

Methodology: A retrospective review of 87 patient files who underwent tracheostomy during the period of January 2023 to December 2023.

Results: After screening, a total of 67 patient files were included in the audit. The median age was 56 years. There were 21 (45.6%) males and 37 (54.4%) females giving a male: female ratio of 0.8 :1. There were 16 emergency tracheostomy cases (27.5%) and 52 (76.4%) elective tracheostomy cases. The concurrent insertion of PEG tube cases were 10 (14.7%) and on current were 58 (85.3%). There were 14 patients with tracheostomy above 60 days (60-270 days). The 7-day mortality was at 5.1%.

Conclusions: The indication for performing a tracheostomy has shifted from being an emergency procedure to a more elective one. The common age of the patients at which tracheostomies are performed remains the elderly. Our data exhibits the skew, likely due to the increased incidence of conditions such as cancer, acute and chronic respiratory or swallowing difficulties in this age. Prolonged mechanical ventilation remains the most common indication for tracheostomy.

Key words: Tracheostomy, Low-resource settings, Audit and quality improvement

INTRODUCTION

Tracheostomy, is a surgical procedure that involves creating an opening in the neck directly into the trachea. It has been a crucial intervention in managing upper airway obstructions and facilitating long-term ventilation. Historically, tracheostomy represented the only treatment available for upper airway obstruction. The first successful tracheostomy was recorded in 1546 by an Italian physician for a patient with a laryngeal abscess. By the mid-1800s, the procedure was commonly performed on children suffering from diphtheria. The technique was further refined and widely accepted through the work of Chevalier Jackson, who established clear indications and standardized techniques for performing tracheostomies[1].

The primary indications for tracheostomy include:

(a) Long-term mechanical ventilation

(b) Weaning failure

(c) Upper airway obstruction

(d) Management of copious secretions

Absolute contraindications such as skin infections and prior major neck surgeries, which obscure the anatomy, must be considered. Complications associated with tracheostomy can be categorized into those related to the procedure itself and those associated with the cannula. Late complications are particularly challenging to quantify due to the critical condition of many patients and loss to follow-up post-discharge before decannulation[2-4].

The objective of this audit was to evaluate the demographics of patients undergoing tracheostomy, assess preoperative evaluations, review concurrent procedures, and determine the 7-day postoperative outcomes. By conducting this audit, we aim to identify areas for improvement, enhance patient

safety, and ensure adherence to best practices in tracheostomy procedures at KUTRRH.

MATERIALS AND METHODS

A retrospective review was conducted on the medical records of patients who underwent tracheostomy at Kenyatta University Teaching, Referral & Research Hospital (KUTRRH) between January 2023 and December 2023. Initially, 87 patient files were identified for review. After data cleaning and validation, 68 files were included in the final analysis.

The data collected from these records included:

Parameter
Age
Sex
Indication for tracheostomy
Type of tracheostomy performed
Preoperative evaluation parameters (e.g., hemoglobin levels, white cell counts, platelet counts)
Duration of the tracheostomy
Seven-day outcome of the procedure

RESULTS

The total number of patients was 68. The median age was 56 years (Missing data n=15). There were 31 males and 37 females, giving a M:F ratio of 0.8:1.

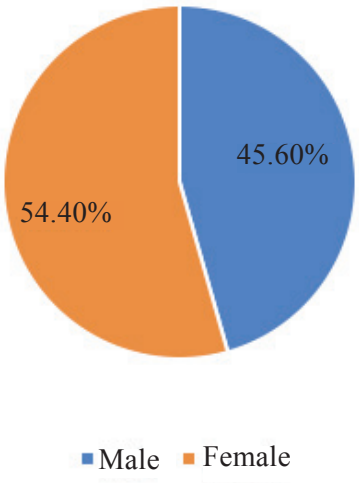


Figure 1: Gender ratio of the patients

The majority of patients came from ICU (n=41) and the rest came from the ward (n=25).

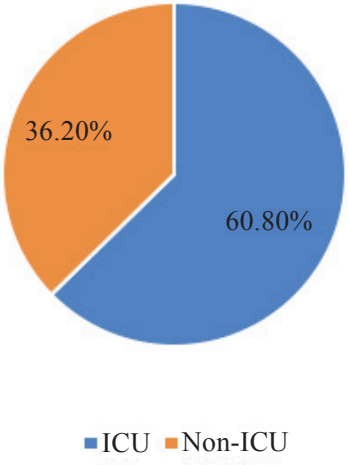


Figure 2: Origin of the patients

In terms of urgency, there were 16 emergencies and 52 elective tracheostomies.

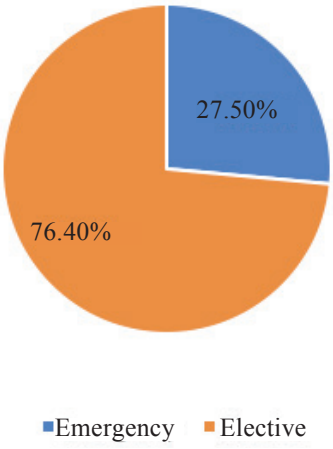


Figure 3: Emergency vs elective tracheostomies

The concurrent insertion of PEG tube was 10 and non-concurrent was 58.

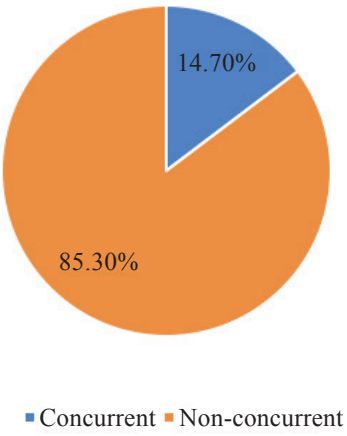


Figure 4: PEG tube insertion

Pre op evaluation (median) was Hb 10.85 g/dL and a minimum of 7.5 g/dL. Forty five percent of patients being between 9.6 and 11.7 g/dL

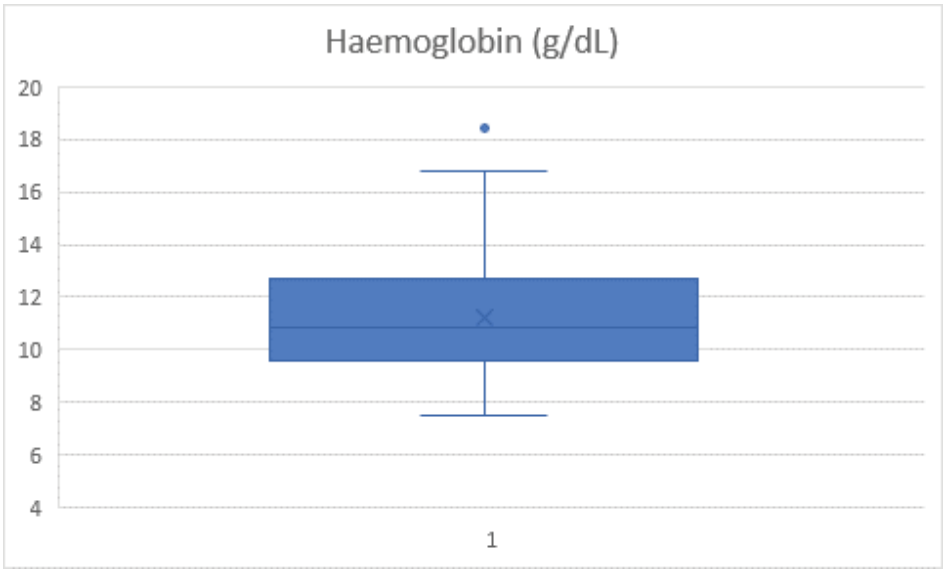


Figure 5: Median haemoglobin level

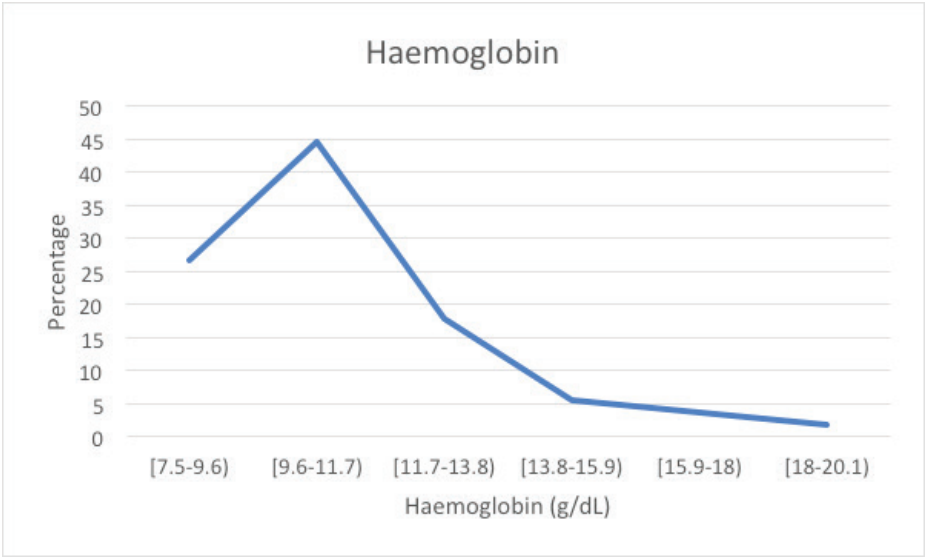


Figure 6: Preoperative haemoglobin levels in the patients

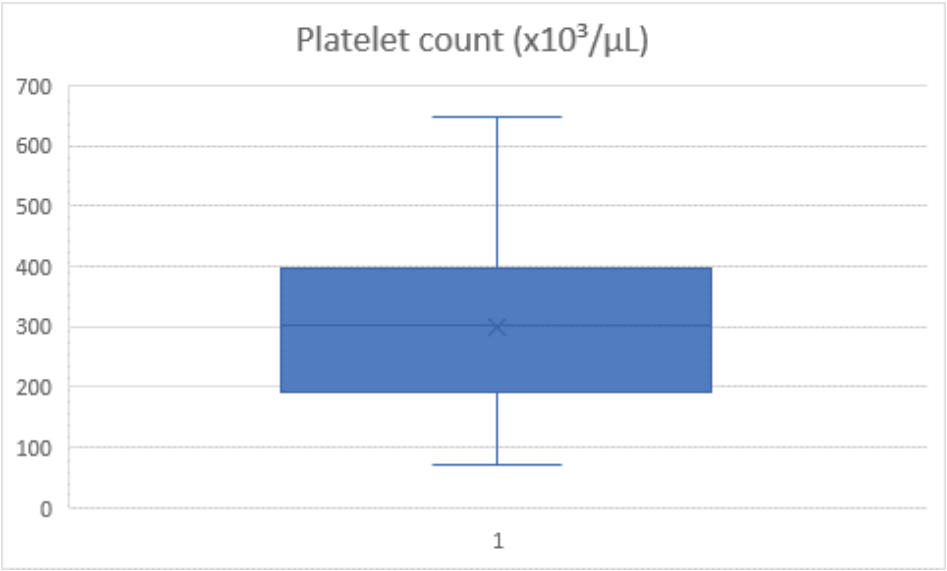


Figure 7: Median platelet count

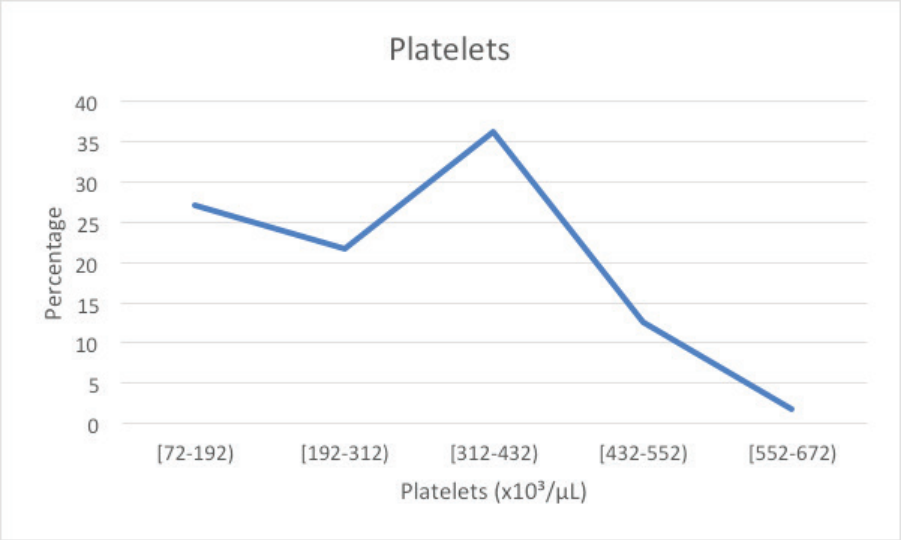


Figure 8: Preoperative platelet count in patients

The median platelet count was 302 x 10^3/µL with 36% of patients being between 314 -432 x 10^3/µL. The minimum was 72 x 10^3/µL. The median white blood cell count was 8.7 x 10^9/L with 46% being in between 5.9-9.7 x 10^9/L. The minimum value was 2.1 x 10^9/L and the maximum value was 23 x 10^9/L.

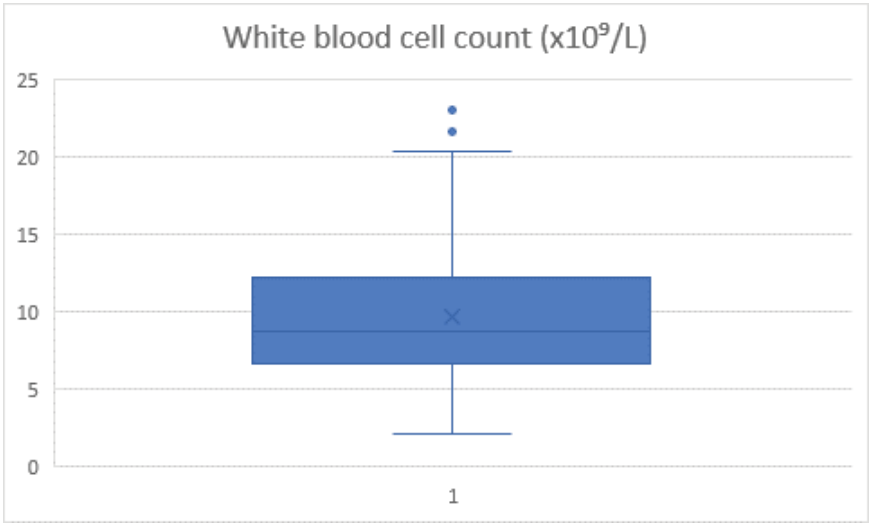


Figure 9: Median white cell count

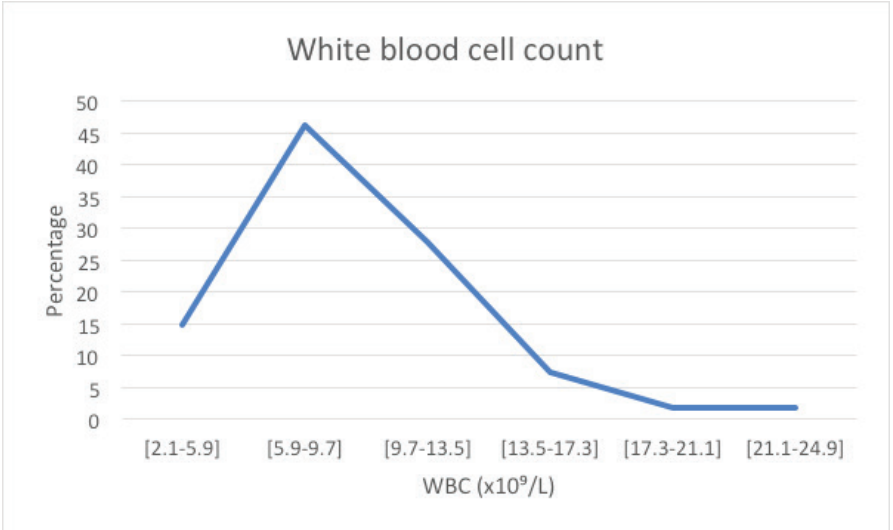


Figure 10: Preoperative white cell count in patients

There was difficulty assessing the duration of tracheostomy due to inconsistent data from the ward and ICU on extubation. However, 14 patients had tracheostomies above 60 days (60 -270 days). The 7-day mortality was 5.1%.

DISCUSSION

The tracheostomy audit at Kenyatta University Teaching, Referral & Research Hospital (KUTRRH) reveals results that are consistent with findings in other low-resource settings, yet also highlights key procedural differences. In KUTRRH's audit, prolonged ventilation was the primary indication for tracheostomy, with a significant portion performed electively (76.4%) rather than as emergencies (27.5%). By comparison, a study conducted by Charles *et al* [2] in Rwanda found that the urgency of tracheostomies often led to higher rates of emergency procedures due to limited ICU and ventilatory support, leading to a higher incidence of immediate complications. Furthermore, KUTRRH's postoperative 7-day mortality rate of 5.1% indicates favorable early survival outcomes, contrasting with studies such as that done by Nyanzi *et al* [3] in Uganda, where postoperative mortality rates were more variable and linked to resource constraints and gaps in critical care. Both the Ugandan and Rwandan studies highlight the importance of strengthening perioperative care and follow-up to mitigate complications in low-resource settings. Although not specific to a low-resource setting, Sue *et al*[4] discusses long-term tracheostomy complications, which are relevant to understanding post-procedure outcomes and care in both high- and low-resource facilities. Bennet *et al*[5] addresses errors in tracheostomy procedures and post-surgical care, providing a useful comparison for settings focusing on minimizing procedure-related complications.

The tracheostomy audit at KUTRRH has enhanced patient care by focusing on thorough preoperative evaluations and tailored protocols for high-risk demographics, particularly elderly patients, to reduce complications and improve outcomes. Tracking a 7-day postoperative mortality rate of 5.1% provides a critical benchmark for evaluating care quality, supporting continuous improvements through audit committee feedback. We aim to introduce percutaneous tracheostomies. This less invasive method could streamline procedures, free up time for the ENT unit, and reduce resource strain, ultimately enhancing care efficiency and reinforcing high standards. Based on these findings, we aim to develop comprehensive protocols that further standardize tracheostomy care, improving patient care, reinforcing high standards and evidence-based practices at KUTRRH.

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A SYSTEMATIC REVIEW ON COMMON CAUSES OF HEARING LOSS AND NEED FOR HEARING AID DEVICE INTERVENTION IN SUB-SAHARAN AFRICA

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ABSTRACT

Background: Countries in sub-Saharan Africa encounter a range of challenges in addressing ear and hearing care. Key issues include the early diagnosis and management of hearing conditions, as well as the timely provision of hearing aids for those in need. These interventions are essential to reduce the impact of disabling hearing loss on individuals and communities. Furthermore, a lack of adequate data significantly impedes the development and implementation of effective policies and practices in ear and hearing care, limiting efforts to improve outcomes for affected populations.

Objective: To address common causes of hearing impairment and its interventional measure on hearing aid usages.

Methods: This systematic review looked at 470 publications published between 2010 and 2023 on the causes of hearing loss and the need for hearing aid device intervention in sub-Saharan Africa. The review followed a procedure for conducting a thorough literature search across databases such as PubMed, MEDLINE, Scopus, and local databases. The study selected publications based on inclusion/exclusion criteria, assessing research design, population characteristics, common causes of hearing loss, prevalence rates, and demand for hearing aids.

Results: A total of 470 records were identified through database searches. After removing duplicates, the titles and abstracts of 144 studies were screened, resulting in the exclusion of 166 records. Ultimately, 30 articles were deemed eligible and included in the review. Infections were the primary cause of hearing loss in many sub-Saharan African countries, accounting for (56.25%), followed by other factors such as medication-related issues (31.25%) and other factors such as impacted earwax and age-related hearing loss constituted (12.5%).

Conclusions: This systematic review investigates the causes of hearing loss in sub-Saharan Africa, that identified infectious diseases, ototoxic medications, noise exposure, and genetic predispositions as major causes of hearing loss. It highlights the critical role of hearing aids in mitigating the effects of hearing loss and enhancing quality of life. The review aims to equip stakeholders with a thorough understanding of the epidemiology of hearing loss, facilitating targeted interventions and strategies for early detection, prevention, awareness, and management. Ultimately, the goal is to improve the overall well-being of the population and ensure better access to hearing healthcare for enhanced quality of life outcomes.

Key words: Sub-Saharan Africa, Hearing loss hearing care, Early diagnosis, Infections, Hearing aid, Quality of life

INTRODUCTION

Hearing loss, a common yet often underestimated sensory condition, affects over 5% of the world's population, or around 430 million people, with a significant impact on speech comprehension and loudness. In sub-Saharan Africa, socioeconomic factors such as poverty, healthcare access, and resource distribution contribute to the prevalence and consequences of hearing loss[1]. Factors such as infectious disorders, untreated ear infections, noise exposure, genetic predispositions, ototoxic drugs, and age-related hearing loss contribute to hearing loss in the region[2]. Ear infections, especially otitis media, are prevalent in the sub-Saharan region due to environmental, social, and economic factors. The warm climate, dust, and air pollutants contribute to the spread of bacteria and viruses, while limited healthcare access in rural communities' delays diagnosis and treatment. Poverty, socioeconomic factors, and poor nutrition contribute to the spread of ear infections[3]. Crowded living conditions, lack of awareness about hygiene, and environmental and social factors like frequent colds and influenza can further exacerbate the issue[2]. Traditional practices, such as unhygienic cleaning tools and reliance on

healers, can also contribute to the spread of ear infections. The high prevalence of ear infections in sub-Saharan Africa is due to limited access to essential vaccines and the high prevalence of HIV/AIDS. Addressing these issues requires improvements in healthcare infrastructure, public awareness, vaccination programs, and targeted health interventions to improve overall health outcomes[4]. It impacts a person's ability to communicate, education, work prospects, and engagement in society. Treatment with proper therapies, such as hearing aids, is essential to minimize negative impacts and improve their quality of life. In sub-Saharan Africa, where many people rely on labour for subsistence, there is an urgent need for accessible, reasonably priced, and culturally suitable hearing aid options. Addressing hearing loss through suitable therapies is crucial for a more inclusive and fair society.

MATERIALS AND METHODS

This systematic review analyzed 470 articles published between 2010 and 2023 on the causes of hearing loss and the necessity of hearing aid device intervention in sub-Saharan Africa. The review used a protocol to conduct a thorough literature search across databases like PubMed, MEDLINE, Scopus, and local databases. The study screened articles based on inclusion/exclusion criteria, evaluating research design, population characteristics, frequent causes of hearing loss, prevalence rates, and demand for hearing aid devices. Keywords used in the search were: hearing loss, deafness, sensorineural hearing loss, otitis media, chronic ear diseases' hearing aid devices, hearing rehabilitation, assistive hearing technology, hearing aid adoption and hearing care services

The review identified gaps in existing research and explored their significance for healthcare in sub-Saharan Africa. The review concluded with recommendations for further research and ideas for policymakers, doctors, and researchers.

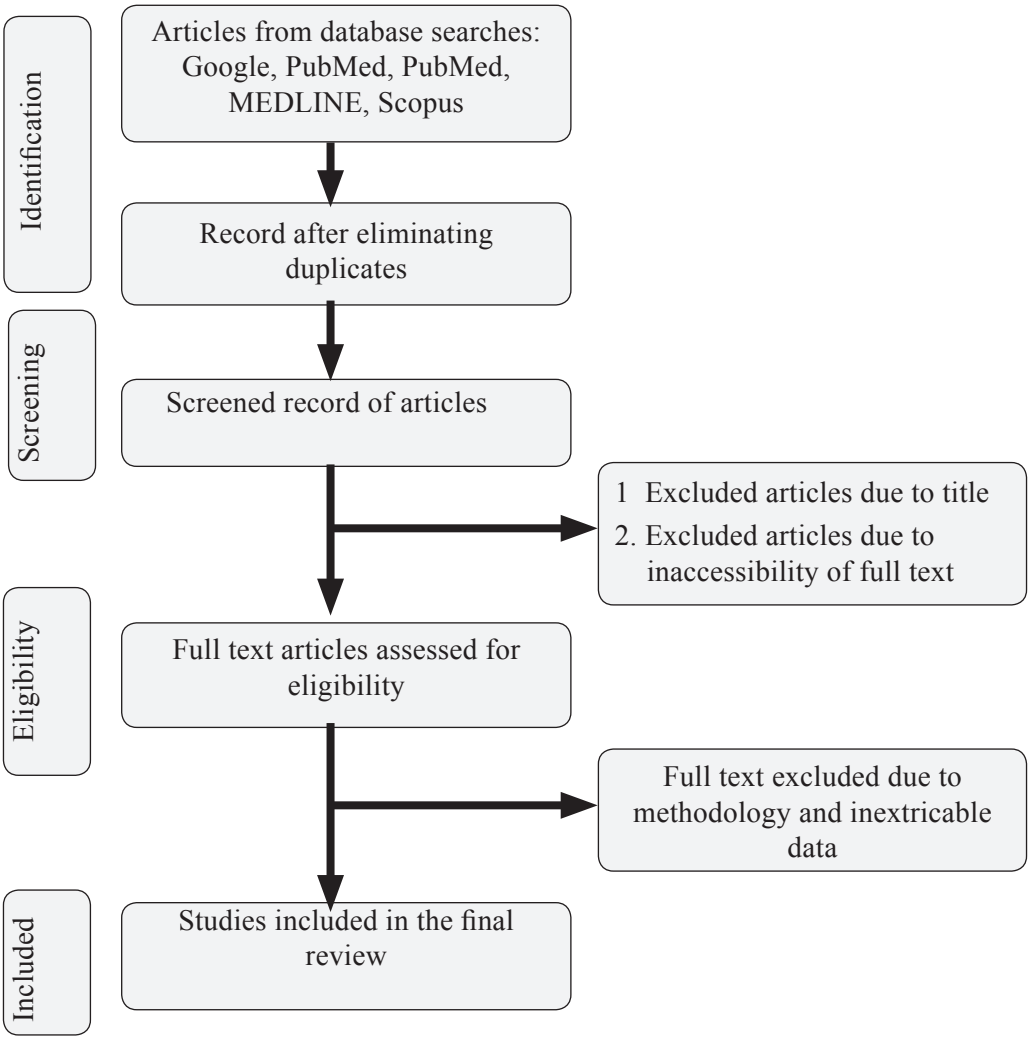


Figure 1: The flow diagram indicating the study selection process

RESULTS

This systematic review evaluates the need for hearing aid interventions in the diverse and complex context of sub-Saharan Africa by thoroughly integrating available information on the common causes of hearing loss. It highlights contributing factors, including infectious diseases, ototoxic medications, noise exposure, and genetic predispositions, through a detailed examination of current data. The review also emphasizes the vital role of hearing aids in mitigating the effects of infectious diseases and ototoxic medications are leading contributors to hearing loss in sub-Saharan Africa, with significant regional variations in prevalence. The data highlights that conditions such as otitis media (e.g., 40% prevalence in Zimbabwe), bacterial meningitis (e.g., 44.4% in Kenya, 30%-87.3% in Niger), and rubella (64.1% in Portugal, which may have implications for African regions with similar challenges) play a considerable role in hearing loss. Furthermore, ototoxic medications, such as anti-TB drugs and aminoglycosides, show high associations with hearing impairment, as evidenced by a 63% prevalence rate for aminoglycoside-induced hearing loss in South Africa and a 52% prevalence rate for anti-TB drug ototoxicity in KwaZulu-Natal. These findings emphasize the need for public health measures aimed at preventing and managing these infections and monitoring the use of ototoxic drugs hearing loss and improving the quality of life for those affected. Age-related and noise-induced hearing loss are major non-infectious factors that necessitate specific prevention and management strategies. Table 1 shows that age-related hearing loss is common, with rates as high as 75% in Nigeria, highlighting the impact of demographic trends and an aging population. Furthermore, noise-induced hearing loss remains a major concern, with 58.5% prevalence in Tanzania and 37% in Zimbabwe. This shows that establishing awareness campaigns and protective measures, such as ear protection and noise control, is critical to lowering the burden of hearing loss caused by environmental and occupational noise exposure.

The findings from this systematic review aim to provide stakeholders, policymakers, and healthcare professionals with a comprehensive understanding of the epidemiology of hearing loss in Sub-Saharan Africa, enabling the development of targeted, data-driven interventions. Additionally, the insights gathered can inform strategies for early detection, prevention, awareness, and effective management of hearing loss, tailored to the unique socioeconomic and cultural landscape of the region. The goal is to enhance the well-being of the population and improve access to quality hearing healthcare. After applying the selection criteria for the causes of hearing loss in Sub-Saharan Africa, 24 articles were identified from a pool of 196 relevant studies on adult hearing loss in Africa, along with 144 articles focused on the causes of hearing loss in the region. Additionally, 17 studies related to hearing aid devices were retrieved, yielding six literature reviews for further analysis.

Hearing Device Usage in sub-Saharan Africa

A total of 17 titles were retrieved with only 6 available for review. Sensory neural sensorineural hearing loss contributed to most of the indication for amplification with relatively satisfactory improved outcomes with usage.

Table 1: Summary of usage of hearing aids this should come at the top as heading of the table

Authors	Year of publication	Country (Region)	Population age	Type of hearing	Number of cases	Outcomes
Kuschke S. Le, Roux T. Swanepoel W	2022	South Africa	0-13 years	SN HL	68 children	Improved wearing daily
Silva Kuschke, Christine Rogers, Estie Meyer-	2023	South Africa	All age group	Conductive	133 children	Improved outcome

Moroe N, Vazzana N	2019	South Africa	74-84 ye.ars	SN HL		Multi factorial Cause of disuse, discomfort, lack of information, difficulty with functional maintenance patient involvement
Amina Seguya, Francis Bajunirwe, Elijah Kakande, Doreen Nakku	2021	Uganda	Newbom	EithK	344l (86%)	High acceptability of hearing aids as an intervention
Vera Genevey Hlayisi, Lebogang Ramma	2019	South Africa	All age group	SN HL	584 (15%)	Need for hearning aids to provide hearing rehabilitation far exceeds the supply
Taiwo Olugbemiga Adedeji, James E Sogebi'Attah Dickens Daniel	2015	Nigeria	1·15 years	SN HL	10	Hearing aid management outcomes are unsatisfactory

Causes of hearing loss in sub-Saharan Africa

In establishing causes of hearing loss in sub-Saharan Africa filters were applied in abstract, free full text and full text where 24 results of 144 were retrieved.

Authors	Year of publication	Country of origin	Cause	Prevalence rate
Wonkam Tingang E, Noubiap JJ, F Fokouo JV, Oluwole OG, Nguefack S, Chimusa ER, Wonkam	2020	Cameroon	Environmental factors meningitis, impacted wax age-related disorder hereditary	unknown
Pedersen CK, Zimani P, Frendø M, Spindler NJ, Chidziva C, von Buchwald C, Jensen RG.	2022	Zimbabwe	Otitis media	40%
Hong H, Dowdy DW, Dooley KE, Francis HW, Budhathoki C, Han HR, Farley JE.	2020	South Africa	DR TB	60%

Ude AE, da Lilly-Tariah OB, Onotai LO, Chinenye	2022	Niger	HIV	28.5%
Caroça C, Vicente V, Campelo P, Chasqueira M, Caria H, Silva S, Paixão P, Paço J.	2017	Portugal	Rubella	64.1%
Olajuyin OA, Olatunya OS, Olajide TG, Olajuyin AB, Olajuyin AA, Babatola AO, Komolafe AK	2021	Nigeria	Measles	45.8%
			Ototoxic medication	32.2%
Ficenec SC, Grant DS, Sumah I, Alhasan F, Yillah MS, Brima J, Konuwa E, Gbakie MA, Kamara FK, Bond NG, Engel EJ, Shaffer JG, Fischer WA, Wohl DA, Emmett SD, Schieffelin JS	2022	Sierra Leone	Ebola	23%
Chadambuka A, Mususa F, Muteti S.	2013	Zimbabwe	Noise induced	37%
Hong H, Dowdy DW, Dooley KE, Francis HW, Budhathoki C, Han HR, Farley JE	2020	Southafrica	Aminoglycoside induced	63%
Karanja BW, Oburra HO, Masinde P, Wamalwa D	2014	Kenya	Bacterial meningitis	44.4%
Abraham Z, Massawe E, Ntunaguzi D, Kahinga A, Mawala S.	2019	Tanzania	Noise induced hearing loss	58.5%
Mateer EJ, Huang C, Shehu NY, Paessler S.	2018	West Africa	Lassa fever	
Pillay S, Naidoo KH, Msimang K.	2021	South Africa	Diabetis mellitus	52%
Hrapcak S, Kuper H, Bartlett P, Devendra A, Makawa A, Kim M, Kazembe P, Ahmed S.	2016	Malawi		24%
Folorunso DF, Dahilo EA, Gbujie IO, Damtong FM, Quadri OA, Nwakwo BE, Ibekwe TS, B Nwaorgu OG.	2020	Nigeria	Age related	75%
Musa TS, Bemu AN, Grema US, Kirfi AM. Pattern of otitis externa in Kaduna Nigeria	2015	Nigeria	Otitis externa	1%
Musa TS, Bemu AN, Grema US, Kirfi AM. Pattern of otitis externa in Kaduna Nigeria				

Iselin Ertzgaard S, Kristin N, Sofie T, Giske Sindberg H, Tobias Bang H, Cosmas M, Tron Vedul T, Aslam N, Jon Ø	2019	Tanzania	Cerumen impaction otitis (all types) Tympanic perforation No abnormalities	 45.5% 45.5% 3 27.3%
		Malawi	Middle ear disease	46.9%
Simões EA, Kiio F, Carosone-Link PJ, Ndegwa SN, Ayugi J, Macharia IM.	2016	Kenya	Otitis media	3.7%
Bamaraki K, Namwagala J, Hidour R, Bambi EN	2022	Uganda	Ome	11%
Jusot JF, Tohon Z, Yazi AA, Collard JM	2013	Niger	Bacterial meningitis N. meningitidis S. pneumoniae	30% 87.3% 11.5%
Appana D, Joseph L, Paken J	2016	Kwazulu Natal	Anti TB drugs ototoxicity	52%

Disease pattern

The study identified the following key areas of causes of hearing loss

Infections

Table 2: Summary of causes of hearing loss

Infections	Rubella, Drug resistance tuberculosis, HIV, Measles, Otitis media, Diabetes, Ebola, Meningitis, Lassa fever
Medications	Ototoxic medications, Anti tuberculosis
Others	Wax impaction, Age related, Idiopathic

Summary of common causes of hearing loss in different countries

Table 3: Pattern of disease-causing hearing loss

Common causes	Description
Infections and diseases	Meningitis, otitis media, and chronic ear infections are common causes, particularly in developing nations with poor access to healthcare resources
Noise-Induced Hearing Loss (NIHL)	Exposure to loud noises in both occupational and recreational settings contributes to hearing impairment. It is a significant issue globally
Ototoxic medications	Hearing loss can result from ototoxic side effects of some medications, such as antibiotics and chemotherapy medications
Aging (Presbycusis)	Due to the natural aging process, age-related hearing loss primarily affects elderly people and is a common cause in both developed and developing countries

Genetic factors	Congenital or later-onset hearing loss is influenced by genetic predispositions and hereditary variables in a number of groups of people
Trauma or injury	Different degrees of hearing loss can be brought on by head injuries, exposure to abrupt loud noises (blast injuries), and accidents
Malformation of the ear	Both congenital and acquired structural defects or abnormalities of the ear can cause auditory impairment
Non-Communicable Diseases (NCD's)	Worldwide-prevalent diseases including diabetes and hypertension can affect hearing health because of vascular and neurological consequences linked to poorly managed NCDs
Excessive use of ear phones/headphones	Hearing loss is a result of the common usage of portable audio devices at loud volumes, especially in younger people
Environmental toxins	Hearing loss can result from exposure to environmental contaminants and poisons, including pesticides and heavy metals. This phenomenon has been documented worldwide

DISCUSSION

The literature sets different criteria for what is considered "normal hearing". The WHO defines normal hearing when the Pure-Tone-Average (PTA) is smaller less than 25 dB HL[1]. In Cape Town, South Africa, the following factors were found to be associated with hearing impairment; male gender, age, hypertension, a history of head and neck trauma and a family history of hearing impairment[5]. Permanent or irreversible sensorineural hearing loss associated with conditions such as noise induced hearing loss in a study by Kitcher *et al*[6] amongst market millers in the city of Accra, Ghana, there was found to be a 24.8% prevalence of significant sensorineural hearing loss and the presence of a 4 kHz audiometric notch among mill workers. The prevalence of hearing loss, which may be characteristic of NIHL in the better hearing ears of the mill workers was 24.8%. In another comparative cross-sectional study in Ghana by Kitcher *et al* [6], where the prevalence rate of noise induced hearing loss among stone crushing workers was about 19.3% for the left ear and 14.3% for the right ear. The level was much higher (90%) as reported in a study in Tanzania by Nyarubeli *et al*[7], on steel workers who were exposed to average noise level of up to 92 dB(A). Minja *et al*[8] found exposer to noise of above 85dB(A) that can cause hearing loss. Age and race were the most important influence factor determining susceptibility to NIHL according to Strauss. *et al*[9] comparatively the prevalence was higher in chili pepper grinders in Lagos, Southwest Nigeria where (62.5%) were confirmed with slight-to-moderate NIHL prevalence[10].

The of hearing loss at a rural province of Zimbabwe constituted conductive hearing loss at (95.1%) and sensorineural hearing loss at (4.9%). Otitis media was the underlying cause in 40% of all cases of hearing loss[11]. Mozambique which is a developing African country Clark[12] found that external auditory canal obstruction was the greatest otoscopic abnormality (regardless of age), followed by severely limited tympanic membrane mobility. The majority of cases in North-West Cameroon have well known causes that are treatable, which had impacted wax playing a major role with 37% conductive causes, while sensorineural causes were less common at (26%)[13.] Determinants of hearing loss severity would enable better management especially if the cause is due to tympanic membrane. The size of perforation was a predictor of hearing loss severity[14]. In a retrospective study by Kuschke *et al*[15] in South African, Western Cape Province, majority presented with conductive hearing loss (64.6%), followed by sensorineural (28.7%) and mixed hearing loss (3.3%) or auditory neuropathy spectrum disorder (3.3%). The most prominent risk factor for conductive hearing loss was otitis media, for sensorineural hearing loss it was a family history of childhood hearing loss, and for auditory neuropathy spectrum disorder it was hyperbilirubinemia supporting other literature supporting causes of conductive hearing loss, in 2007 a study done in Egypt otitis media with effusion (30.8%) was the commonest cause of hearing loss, followed by presbycusis (22.7%)[16]. In Nigeria 57.1%

had OME, 33.8% had CSOM, (9.1%) had AOM otitis media is an important cause of preventable hearing loss in developing countries and in most studies the findings are relatively similar[17].

In a study by Smith *et al*[18] for HIV + children in Addis Ababa, Ethiopia, hearing was significantly worse in HIV + children. Chronic OM, conductive and mixed hearing losses are significantly more common in HAART-treated HIV + children than in well[18]. In the HIV + cohort 17.8% had evidence of TM perforations and 8.4% had otorrhea. Olusanya *et al*[10] established a positive predictive value of 25.0% for identifying SNHL among infants with severe neonatal jaundice in Lagos, Nigeria where fourteen (6.0%) of the 234 infants with neonatal jaundice (2.1%) were confirmed to have SNHL[10]. To prevent or detect the onset of hearing loss amongst patients using amikacin in the long-term MDR-TB treatment it was established that it led to a higher risk of occurrence of severe forms of hearing loss compared to kanamycin use with a cumulative incidence of 58 % with any form of hearing loss[19].

In Malawi hearing aid coverage was <1% due to lack of perceived need[22]. The need for hearing aids to provide hearing rehabilitation far exceeds the supply as established by Ramma *et al*[5] and Hlayisi *et al*[21] suggesting a multi-pronged approach that includes increased budget allocation and exploring low-cost interventions for developing countries to meet the demand for hearing aids. Sensorineural hearing loss of 30 dB and above was demonstrated in (40%) of sickle cell anaemia patients[22], in Kenya comparatively to a lesser prevalence in Ghana of about 29% of the sickle cell patients studied showed hearing losses ranging from 30 to 60 dB in the high frequency range of 4 to 8 kHz[23].

The majority of elderly patients complained of hearing impairment for patients aged 90 years and older in Egypt the prevalence (78.6%)[24], which is in concurrence with worldwide studies that report presbycusis is a common cause of hearing loss in adults. Age related hearing loss from age 55 years and above at Gwagwalada Area Council, of FCT, Abuja was 75.0%[25].

Ototoxicity remains prevalent in the developing countries of Africa. Numerous drugs are responsible for drug induced ototoxicity in the study by Kokong *et al*[26]. The most common agents established were chloramphenicol at 16.0%, chloroquine 14.1%, and gentamicin 12.8%. where those affected with profound sensorineural hearing loss were (49.7%). Mixed hearing loss was seen in (28.8%)[26]. Although there were no direct studies related to cisplatin induced hearing loss, the use of higher cumulative cisplatin dosages was associated with development of significant hearing loss[27].

A meta-analysis of articles published in PubMed entailed eight studies of South Africa, Botswana and Namibia and published between 2012 and 2016 showed individuals with MDR-TB and HIV coinfection had a 22% higher risk of developing AG-induced hearing loss than non-HIV-infected individuals[28].

Rubella is a disease that can be prevented. In Africa, only a few countries routinely immunize against rubella, although in a study by Caroça *et al*[29] did not establish a cause-effect relationship between rubella infection and sensorineural hearing loss (SNHL) however 62.6% were positive for the rubella IgG. In Angola the commonest cause of hearing impairment was measles (63.3%)[30]. Studies in Africa have shown that N. meningitidis could cause hearing loss in Niger subjects exposed to acute bacterial meningitis were reported to have hearing loss that significantly disabled 31.3% of the exposed subjects and 10.4% exhibited a serious deafness[31].

In summary most causes of hearing loss in developing countries are preventable and the most common cause of conductive hearing loss recorded in this study was otitis followed by wax impaction. Other causes include ototoxic medication age related hearing loss, noise induced hearing loss and infections with rubella, measles, bacterial meningitis.

CONCLUSION

Hearing loss in sub-Saharan Africa is a growing concern due to infections, ototoxic medications, and age-related impacts. To address this, African countries should develop policies, support early detection and prevention, enhance healthcare infrastructure, and reduce noise pollution. Collaborative efforts, partnerships, and continuous monitoring are essential for translating these implications into actionable policies and practices.

Study limitation

This systematic review on hearing loss in sub-Saharan Africa faces limitations such as reliance on previous work, publication bias, data availability differences, heterogeneity, inherent biases, and population and demographic variability.

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MANAGEMENT OF PARAPHARYNGEAL TUMOURS: CASE REPORTS

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ABSTRACT

Tumours of parapharyngeal space are rare in the head and neck region with presentation varying from patient to patient. The course is usually indolent with presentation at an advanced stage as the region is hidden out of site by bony boundaries. Different radiological modalities are available for investigating these lesions. Surgical resection is the mainstay of management for the vast majority of patients. This is however challenging due to various factors that range from tumour size, location in the space, malignancy, surgical expertise and history of previous management. The bony anatomical boundaries in the superior and lateral borders make the space relatively inaccessible while the neurovascular structures that traverse the region further complicate surgical dissection of this space. Different surgical approaches are used to access this space, each with its merits and demerits. This case presents a case series of nine patients with parapharyngeal tumours managed discussing the different approaches used.

Key words: Parapharyngeal, Transmandibular, Transparotid, Cervical

INTRODUCTION

The parapharyngeal space (PPS) takes the form of an inverted pyramid with the superior limit at the skull base and the tip at the greater cornu of the Hyoid as the inferior one. The superior constrictor covered by the buccopharyngeal fascia forms the medial border. The lateral border is formed by superficial layer of the deep cervical fascia separating it from the masticator space. The posterior border is the prevertebral fascia and anteriorly is the pharyngomandibular raphae. It is divided into prestyloid and poststyloid spaces by fascia extending from the styloid process to the Tensor veli palati muscle. The prestyloid space contains the deep lobe of the parotid, fat and lymphatics while the post styloid space contains the carotid artery, cranial nerves IX, X, XI and XII. The contents dictate the likely type of tumour to arise in the respective space with a wide variety of tumours likely to develop in the PPS from the different tissues present in the respective spaces. Pleomorphic adenoma is the likely tumour to arise in the prestyloid space while neurogenic and vascular tumours are more likely in the post styloid space.

Presentation of PPS lesions vary from an intraoral or neck mass, dysphagia, globus pharyngeus, difficulties in breathing, hoarsness and hearing loss due to eustachian tube dysfunction. Malignant lesions may present with neck nodes. Various investigation modalities are available for PPS lesions. CT scan and MRI are widely used for PPS investigation. Each has its advantages and are occasionally used together for preoperative planning of surgical management.

Surgical resection is the mainstay of management for PPS lesions. There are different approaches for resecting these lesions the choice being determined by size of the lesion, location and surgical expertise. Surgery is however complicated by presence of major vessels, cranial nerves and space restrictions by the mandible and skull base[1]. This is a case series of patients with PPS tumours we managed in our institution.

CASE REPORTS

Demographics and presentation

There were 5 males and 4 female patients that were managed during the three year and seven months period. The age range was 2 to 55 years with an average of 23 years. Thirty three percent of the cases were below the age of 4 years while the remaining were adults. Majority of the patients [66%] presented with history of a neck mass. The earliest presentation was in the youngest patient who had the symptom for 9 months. The longest presentation was in an adult who had the presentation with a left neck mass for 3 years. Three patients had peculiar presentation of ear fullness, an external auditory canal mass and dysphonia. One patient had an incidental parapharyngeal mass picked while being investigated for upper limb weakness. This mass

had the longest dimension of 20mm and was medial to the deep lobe of the parotid gland with an intact facial nerve function.

Preoperative imaging

Two patients had CT scan preoperatively while the remaining 7 had MRI scans preoperatively. One patient had in addition a CT angiography as the lesion was deemed to be vascular and therefore preoperative embolization had been recommended. The lesion was however found not to be vascular and thus not embolized. This patient had received external beam radiation as treatment for his lesion from an external facility with disease progression at the time of presentation to our facility.

Sex	Age (years)	Presentation	Size	Approach
Male	37	Left neck mass for 3 years	70x54x70	Cervical
Female	55	Right ear fullness for 2 years		Transmandibular
Male	18	Left ear canal mass, tinnitus and discharge for 1and ½ years	76x69x46	Transmandibular
Female	2.5	Left neck mass with airway obstruction 1.5 years	90x50x55	Transmandibular
Male	17	Left neck mass for 2.5 years	68x39x61	Transmandibular
Male	24	Dysphonia and dysphagia for one month	66x55x31	Transmandibular
Female	29	Incidental mass on MRI	20X15X10	Transparotid
Male	2	Right neck mass 9 months	110x90x45	Transcervical
Male	4	Left neck mass	90x70x35	Transcervical

FNAC	Histology	Trach	NG tube	Duration	Complications
Spindle cell neoplasm	Hemangiopericytoma	Nil	Nil	3 days	Hypertrophic scar
Pleomorphic adenoma	Solitary fibrous tumour	5 days	3 days	9 days	Marginal mandibular palsy
Not done	Myxoma	7 days	18 days	21 days	Hypoglossal palsy
Soft tissue tumor	Low grade spindle cell	22 days	16 days	18 days	Buccal branch palsy
Not done	Pleomorphic adenoma	3 days	7 days	7 days	Hypertrophic scar
Not done	Schwanoma	6 days	12 days	14 days	Hypoglossal nerve
Not done	Pleomorphic adenoma	Nil	Nil	3 days	Nil
Not done	Ganglioneuroblastoma	Nil	Nil	8 days	Hypoglossal nerve palsy
Not done	Ganglioneuroma	2 days	Nil	8 days	Hypoglossal nerve palsy

Surgical management

Preoperative counselling was done pointing out possible complications including aesthetics for patients planned for the transmandibular approach. All the operations were done under general anaesthesia none of whom had any perioperative complication. Six patients had a tracheostomy fashioned at the beginning of the operation. All the five patients whose approach was transmandibular had a preoperative tracheostomy while the sixth had the tumour extirpated through a cervical approach. Three patients who didn't have a preoperative tracheostomy had the PPS tumour approached

cervically for two cases while the remaining one had the mass approached via the transparotid approach. The earliest decannulatilon was after 2 days while the longest was retained for 22 days.

Nasogastric tube was inserted in 5 patients for postoperative feeding. This was removed when that patient was observed to be able to feed orally. The earliest removal was after 3 days while the patient with the longest retention was 18 days.

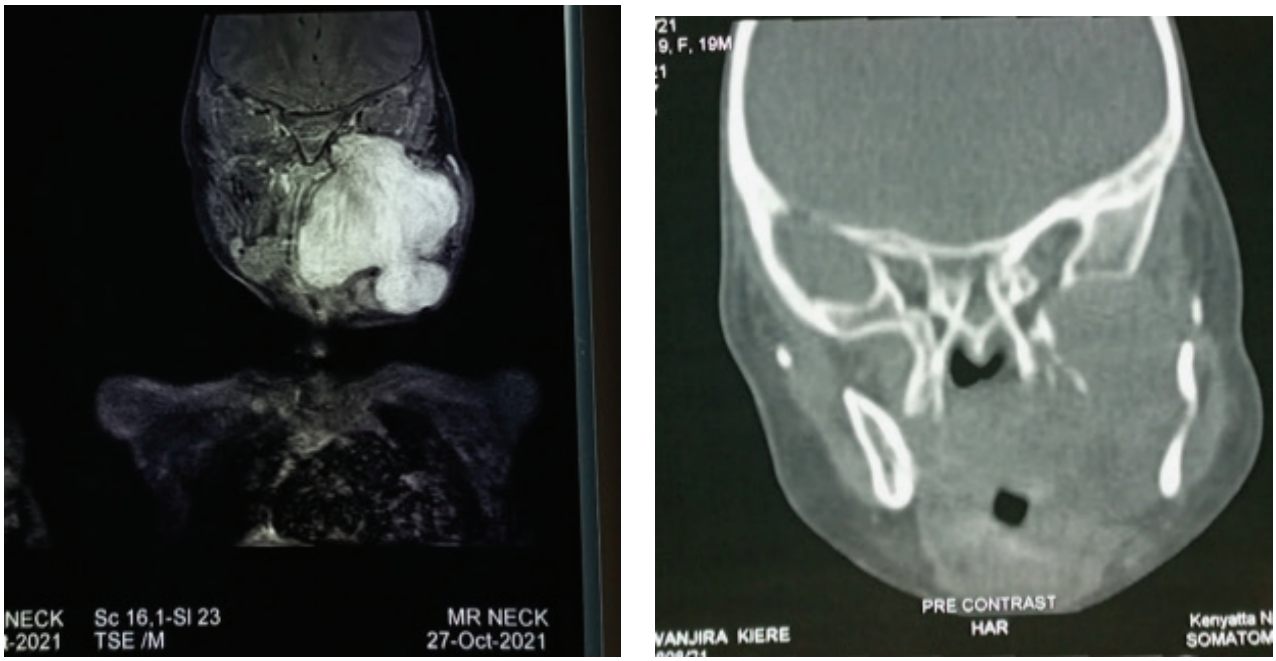


Figure 1: [Imaging modalities] Coronal cuts of the same patient showing better tissue definition in MRI compared to CT scan



Figure 2: [Transmandibular approach]. Buccal flap elevated up to the mental nerve [marked by white arrow]. The plate is prefixed prior to mandibulotomy



Figure 3: [Transmandibular approach] Mandibulotomy and lateral retraction of the mandible exposing the PPS lesion [L]. Plate fixing the mandible in the position predetermined prior to mandibulotomy

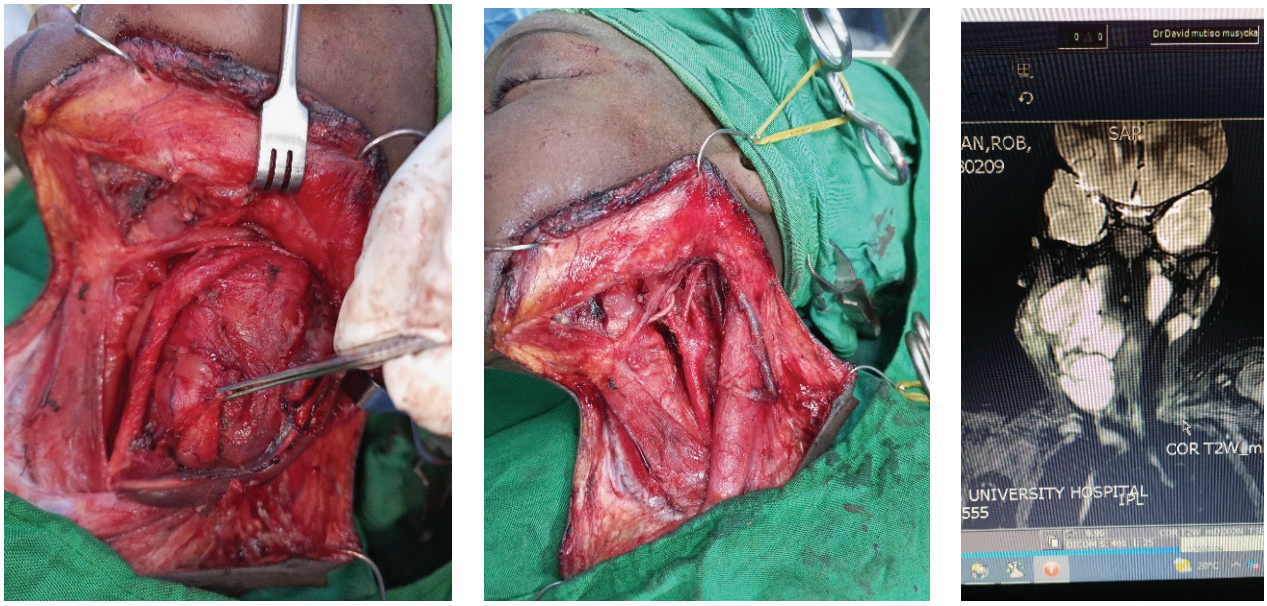


Figure 4: [Cervical approach]. PPS lesion extending into the cervical region. Cervical approach used to excise the lesion that extended to the skull base as is shown by the MRI image

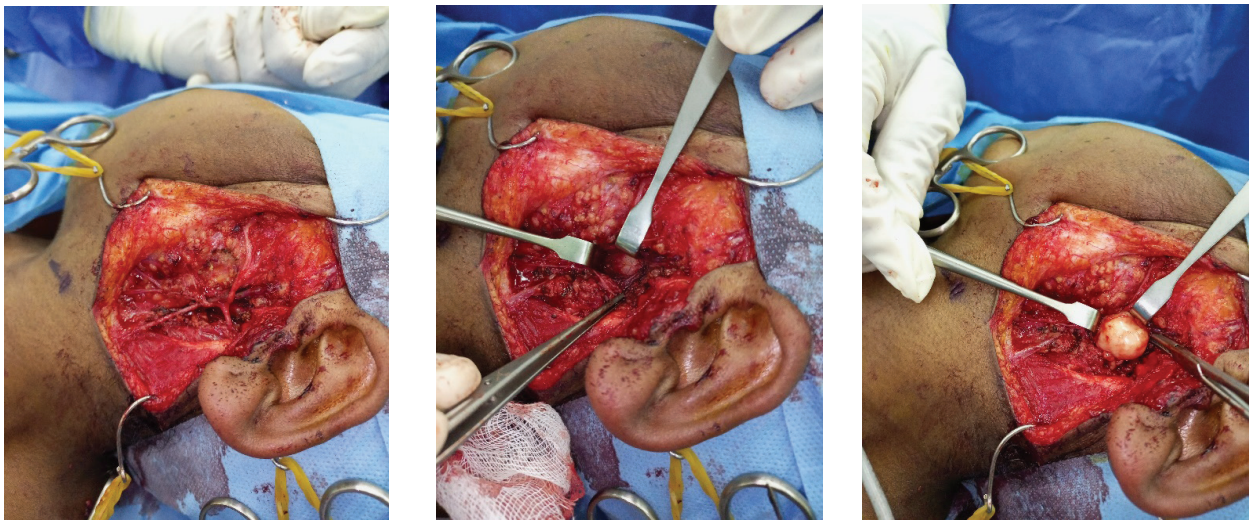


Figure 5: [The transparotid approach]. The branches of the facial nerve post superficial parotidectomy with the PPS exposed after retraction of the facial nerve branches. The mass is then delivered between the branches.

DISCUSSION

Tumours of the PPS are rare accounting for about 0.5 to 1% of all head and neck tumours[2]. Various radiological modalities are available for investigating PPS lesions[3]. MRI has good soft tissue definition and is useful to evaluate for skull base invasion and gives excellent information relating to nearby anatomical structures. CT scan is excellent for evaluation of bone invasions but is inferior to MRI in soft tissue definition[3]. It is however cheaper and easier to perform as compared to MRI (Figure 1). Fat content in the PPS is easily picked on radiology being hyperintense on T1 taking a triangular shape on axial cuts. This is useful in radiologic interpretation of lesions in the suprahyoid neck as the direction of displacement of this fat enables prediction of the origin of lesions in this region. Lesions arising in the masticator space are likely to displace the PPS posteromedial[4]. Parotid space lesions displace the PPS medially while those arising from the pharyngeal mucosal space do so laterally. Lesions in the carotid space with displace the PPS anteriorly. The convexity of the fat pad will be in the direction of displacement[5]. Displacement of the internal carotid artery on imaging may be helpful in the preoperative setting as neuromas will displace the vessel anteriorly while salivary gland tumours displace it posteriorly[6]. Tumours with irregular margins, those with invasion of the surrounding structure and nodal metastasis are some of the radiological findings that increase the likelihood of malignancy. PET scan may be used to evaluate for suspected distant metastasis in malignant PPS lesions[7].

FNAC is important in management of head and neck tumours as it may give guidance regarding approach and extend of surgery. A lesion confirmed to being malignant is best approached through wide exposure and excellent vascular control to enable resection with clear margins while avoiding tumour spillage. Neck dissection may be necessary in this setting. Despite this, the place of FNAC in PPS lesions is limited as the region is concealed by the bony anatomical confines on the lateral and superior borders. It is however possible to acquire material by FNAC for PPS that deform the oropharyngeal or cervical spaces. The carotid artery and internal Jugular vein in the post styloid compartment makes FNAC risky if not performed by ultrasound guidance. Lymphomas and inflammatory conditions may be diagnosed from FNAC and thus negate surgery as the appropriate management is medical[8].

The mainstay of management of PPS tumours is surgery. Just like FNAC, this is complicated by the bony confines of the space in addition to the major neurovascular structure that traverse this anatomical space. Surgical expertise, size of the lesion, location in the PPS and involvement of the facial nerve are some of the factors that come into play when planning for surgery. The transmandibular approach offers wide exposure of the PPS with excellent neurovascular exposure and control. It is suitable for lesions located high up in the PPS approaching the skull base as these are technically difficult to dissect through the cervical approach. It is also suitable for malignant lesions where there is a desire for complete excision without tumour seeding. Vascular lesions are best approached via this approach because of

excellent exposure that allows neurovascular control. Cases of recurrent PPS lesions may require this approach due to presence of fibrosis which makes dissection challenging with the likelihood of bleeding and trauma to nearby structures like nerves. This is evident in tumours previously treated with surgery or radiation. One of our patients managed with this approach had received irradiation as therapy for tumour management[9]. Tracheostomy is fashioned at the beginning of the procedure for ventilation. This frees the oral cavity for surgery as an endotracheal tube would be in the operation site in addition to compromising sterility. It is however possible to have a nasotracheal tube to achieve similar goals with tracheostomy being fashioned at the end of the operation. Tracheostomy secures the airway in the postoperative period that may be compromised due to post operative edema. The submandibular flap is elevated ensuring the posterior limb is at least two finger breaths below the angle of mandible to protect the marginal mandibular nerve. The author prefers starting by performing a Level 1 to 3 neck dissection to expose the neurovascular structures in the neck which enables exposure of the parapharyngeal after the mandible is swung. The neck dissection specimen is submitted for histopathology alongside the PPS lesion. Acid fast bacilli was found in one of the samples who had the primary lesion report of pleomorphic adenoma. Anti TB management was instituted postoperatively. The lip flap is elevated to the mental nerve, prefixing the plate done and mandibulotomy done between the canine and first premolar. The author prefers a straight mandibulomy as opposed to a stepped or angulated one as stability is ensured by the 6 screws distributed equally on either side of the cut. Angulation or stepping may injure the roots resulting in unnecessary loss of dentition. In all the mandibulotomies, no tooth was excised. Prefixing the plate marks the exact position of the plate to avoid malocclusion because mandibulotomy results in loss of bone (Figure 2). Lateral retraction of the mandible and incision of the floor of the mouth allows access to the PPS with excellent exposure of the carotid, internal jugular and the last four cranial nerves (Figure 3). Closure of the wound is done once the tumour is resected with a nasogastric tube inserted at the end of the operation for feeding.

The cervical approach accesses the PPS through the submandibular region. This approach is appropriate for lesions in the lower half of the PPS. The procedure starts with a submandibular incision with the posterior limb being at least two finger breaths below the angle of mandible to ensure protection of the marginal mandibular nerve. The subplatysmal flap is elevated to expose the submandibular gland and the mass if the lower portion is in the neck. It may be necessary to excise the submandibular gland to gain access to the PPS. Transection of the stylomandibular ligament to gain additional space with lateral retraction of the mandible may be done. Blunt dissection using a finger is then used to deliver the mass. This is a relatively blind procedure with no control of the neurovascular structures in the PPS. Two patients both children, with extensive PPS lesions spanning from the skull base to the cervical region were managed via the cervical approach. The operation started with a level 1 to 3 neck dissection to expose the cervical neurovascular bundle. The neck mass was dissected out separating it from the common carotid and internal jugular vein. The mass was then dissected out superiorly good retraction offering exposure up to the superior edge at the skull base (Figure 4).

The transparotid approach is used for lesions in the prestyloid compartment of the PPS. It is appropriate for lesions medial to the deep lobe of the parotid gland. Tumours arising from the deep lobe of the parotid will not have a fat pad between the lesion and the gland. The operation starts with superficial parotidectomy exposing all the branches of the facial nerve. The lesion will then be dissected in the deep lobe of the parotid and then delivered between the branches of the facial nerve. Lesions that are larger than 4 cm are not appropriate for this approach as it would be technically difficult to deliver between the facial nerve branches. Such a lesion may be delivered medially after being freed from the facial nerve (Figure 5).

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Ethics and consent: Approval for the publication and consent from the patients was acquired.

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