RELIABILITY OF

ENDOSCOPIC A.C.E. GRADING SYSTEM

OF ADENOIDS

A dissertation submitted in partial fulfilment of MS Branch IV, ENT examination of the Tamil Nadu Dr. M.G.R. Medical University, to be held in May 2018

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DEPARTMENT OF OTORHINOLARYNGOLOGY

CHRISTIAN MEDICAL COLLEGE

VELLORE

CERTIFICATE

This is to certify that the dissertation **"RELIABILITY OF ENDOSCOPIC A.C.E. GRADING SYSTEM OF ADENOIDS"** is the bona fide original work of **Dr. Joby Elizabeth Ninan**, carried out under my guidance, submitted in partial fulfilment of the rules and regulations for the **MS Branch IV**, **ENT** examination of the Tamil Nadu Dr. M.G.R. Medical University, to be held in May 2018.

Dr. Mary John

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Dr. Anna B. Pulimood

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DECLARATION

I, Joby Elizabeth Ninan, do hereby declare that the dissertation titled **"RELIABILITY OF ENDOSCOPIC A.C.E. GRADING SYSTEM OF ADENOIDS"** submitted towards partial fulfilment of the requirements of the Tamil Nadu Dr. M.G.R. Medical University for the MS Branch IV, Otorhinolaryngology examination to be conducted in May 2018, is the bona fide work done by me, and due acknowledgements have been made in text to all materials.

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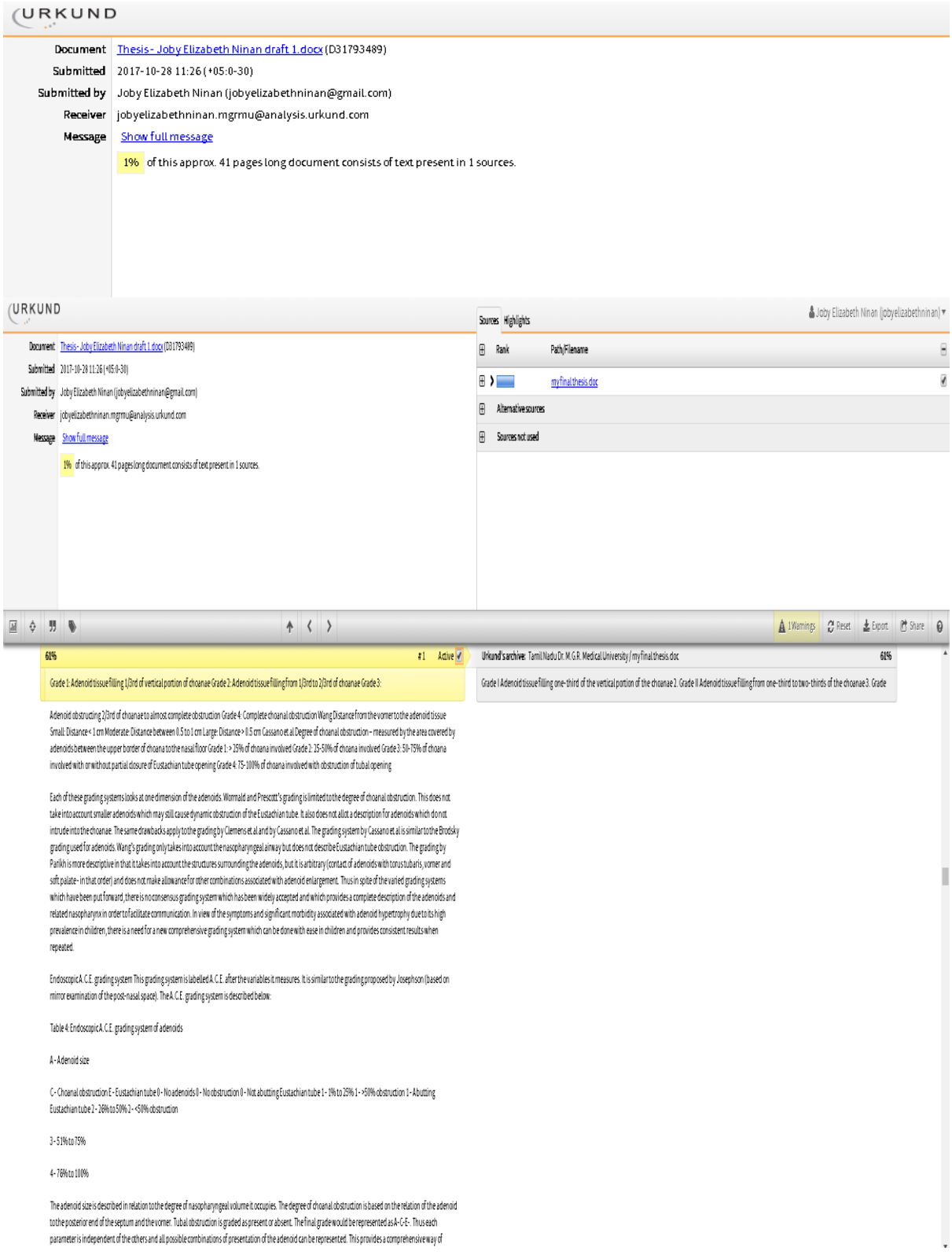

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Grade I: Adenoid tissue filling 1/3rd of vertical portion of choanae Grade 2: Adenoid tissue filling from 1/3rd to 2/3rd of choanae Grade 3:

Grade I Adenoid tissue filling one-third of the vertical portion of the choanae 2. Grade II Adenoid tissue filling from one-third to two-thirds of the choanae 3. Grade

Adenoid obstructing 2/3rd of choanae to almost complete obstruction Grade 4: Complete choanal obstruction Wang Distance from the vomer to the adenoid tissue Small: Distance< 1 cm Moderate: Distance between 0.5 to 1 cm Large: Distance> 0.5 cm Cassano et al Degree of choanal obstruction – measured by the area covered by adenoids between the upper border of choana to the nasal floor Grade 1: > 25% of choana involved Grade 2: 25-50% of choana involved Grade 3: 50-75% of choana involved with or without partial closure of Eustachian tube opening Grade 4: 75-100% of choana involved with obstruction of tubal opening

Each of these grading systems looks at one dimension of the adenoids. Wormald and Prescott's grading is limited to the degree of choanal obstruction. This does not take into account smaller adenoids which may still cause dynamic obstruction of the Eustachian tube. It also does not allot a description for adenoids which do not intrude into the choanae. The same drawbacks apply to the grading by Clemens et al and by Cassano et al. The grading system by Cassano et al is similar to the Brodsky grading used for adenoids. Wang's grading only takes into account the nasopharyngeal airway but does not describe Eustachian tube obstruction. The grading by Parikh is more descriptive in that it takes into account the structures surrounding the adenoids, but it is arbitrary (contact of adenoids with torus tubaris, vomer and soft palate - in that order) and does not make allowance for other combinations associated with adenoid enlargement. Thus in spite of the varied grading systems which have been put forward, there is no consensus grading system which has been widely accepted and which provides a complete description of the adenoids and related nasopharynx in order to facilitate communication. In view of the symptoms and significant morbidity associated with adenoid hypertrophy due to its high prevalence in children, there is a need for a new comprehensive grading system which can be done with ease in children and provides consistent results when repeated.

Endoscopic A. C.E. grading system This grading system is labelled A. C.E. after the variables it measures. It is similar to the grading proposed by Josephson (based on mirror examination of the post-nasal space). The A. C.E. grading system is described below:

Table 4: Endoscopic A. C.E. grading system of adenoids

A - Adenoid size

C - Choanal obstruction E - Eustachian tube 0 - No adenoids 0 - No obstruction 0 - Not abutting Eustachian tube 1 - 1% to 25% 1 - >50% obstruction 1 - Abutting Eustachian tube 2 - 26% to 50% 2 - <50% obstruction

3 - 51% to 75%

4 - 76% to 100%

The adenoid size is described in relation to the degree of nasopharyngeal volume it occupies. The degree of choanal obstruction is based on the relation of the adenoid to the posterior end of the septum and the vomer. Tubal obstruction is graded as present or absent. The final grade would be represented as A-C-E- Thus each parameter is independent of the others and all possible combinations of presentation of the adenoid can be represented. This provides a comprehensive way of

ACKNOWLEDGEMENTS

I take this opportunity to thank God Almighty for giving me this opportunity, for being with me through each step and helping me to complete this dissertation.

I wish to express my sincere gratitude to my guide Dr. Mary John, Professor, Department of Otorhinolaryngology, Christian Medical College and Hospital, Vellore, for her constant support, motivation, hard work, meticulous guidance and encouragement, without which this dissertation would not have been possible.

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Dr. Joby Elizabeth Ninan, Emp. No: 29200, PG Registrar, ENT, Dr. Mary John, Emp. No: 30859, Dr. Naina Picardo, Emp. No: 31572, Dr. John Mathew, Emp. No: 52458, Department of ENT, Mrs. Grace Rebekah, Employment Number: 32070 , Statistician..

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Dear Dr. Joby Elizabeth Ninan,

I enclose the following documents:-

1. Institutional Review Board approval 2. Agreement

Could you please sign the agreement and send it to Dr. Biju George, Addl. Vice Principal (Research), so that the grant money can be released.

With best wishes,

Dr. Biju George
Secretary (Ethics Committee)
Institutional Review Board

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SECRETARY - (ETHICS COMMITTEE)
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Dear Dr. Joby Elizabeth Ninan,

The Institutional Review Board (Blue, Research and Ethics Committee) of the Christian Medical College, Vellore, reviewed and discussed your project titled "Reliability of new endoscopic adenoid granding system" on September 05th 2016.

The Committee reviewed the following documents:

1. IRB Application format
2. Cvs of Drs. Joby, John Mathew, Mary John, Naina Picardo.
3. No. of documents 1 - 2

The following Institutional Review Board (Blue, Research & Ethics Committee) members were present at the meeting held on September 05th 2016 in the C K Job Hall, Paul Brand Building, Christian Medical College, Bagayam, Vellore 632002.

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Dr. Anuradha Rose	MBBS, MD, MHSC (Bioethics)	Associate Professor, Community Health, CMC, Vellore	Internal, Clinician
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Dr. Ranjith K Moorthy	MBBS, MCh	Professor, Neurological Sciences, CMC, Vellore	Internal, Clinician

We approve the project to be conducted as presented.

Kindly provide the total number of patients enrolled in your study and the total number of withdrawals for the study entitled: "Reliability of new endoscopic adenoid granding system" on a monthly basis. Please send copies of this to the Research Office (research@cmcvellore.ac.in).

Fluid Grant Allocation:

A sum of 34,500/- INR (Rupees Thirty four Thousand five hundred Only) will be granted for 24 Months.

Yours sincerely,

Dr. Biju George
Secretary (Ethics Committee)
Institutional Review Board

Dr. BIJU GEORGE
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INTRODUCTION

The adenoids are a part of the Waldeyer's ring and play an important part in the development of the immune system and in the defense against infection. Adenoid enlargement is common in children, particularly due to the normal growth pattern and changes of the adenoids in relation to the nasopharynx, and also due to associated factors like allergy and surface biofilm formation. Their location at the junction of the nasal passage and the oropharynx predisposes to a variety of symptoms when enlarged, including snoring, mouth breathing, recurrent colds and sinusitis, recurrent ear infections including acute otitis media and otitis media with effusion, chronic otitis media and recurrent pharyngotonsillitis. Thus, they contribute significantly to morbidity among children in the first two decades of life. Being located on the posterosuperior roof of the nasopharynx, the adenoids are not amenable to easy clinical visualization. Among the various investigations in use to assess adenoid hypertrophy, lateral radiographs of the nasopharynx and video nasopharyngoscopy are the most common tests in use. The lateral radiographs are useful in screening children, although video nasopharyngoscopy using the rigid or flexible fibreoptic endoscopes has become the gold standard due to the completeness of the picture obtained and the opportunity it affords to look at other areas of interest in the nose, nasopharynx and oropharynx. However, there is no universally accepted grading system for the adenoids using the endoscope which has been described in the extant literature. The various systems which have been proposed for endoscopic evaluation have been limited by their inability to provide a complete description of the adenoids in relation to the areas of expected mass effect due to adenoid enlargement. The proposed ACE

grading system is intended to fill this gap, and to be a grading system which can be easily used in the theatre and in the clinical setting to provide a complete picture of the degree of adenoid enlargement and its impingement on nearby structures. It assesses three variables – the adenoid size in relation to the nasopharyngeal volume (A), the degree of choanal obstruction (C), and the presence of Eustachian tubal obstruction (E). The original study which proposed this grading system was done on patients under general anaesthesia. Hence there is a need to assess the reliability of this grading system, as well as its usefulness regardless of the expertise level of the rater, and its possible use in the out-patient department as an evaluative tool to plan for management. Hence this study was conducted.

AIMS AND OBJECTIVES

Aim:

To assess the reliability of the ACE endoscopic grading system of adenoids.

Objectives

1) To assess the inter-rater reliability of the ACE grading system of adenoids.

2) To assess the intra-rater variability of the ACE grading system of adenoids.

3) To quantify the agreement between different levels of expertise when using the ACE grading.

4) To compare the ACE grading obtained under general anaesthesia in the operation theatre (standard grade) with the grading obtained under local anaesthesia in out-patient department.

REVIEW OF LITERATURE

The adenoids form a part of normal lymphoid tissue in humans. It plays an important role in the development of immunity. It also has a role in several disease processes. This is a review of its place among the other lymphoid tissue of the head and neck, its normal development and the factors associated with disease, including symptoms and clinical management. There are a variety of evaluation methods described to diagnose enlarged adenoids, as well as diverse treatment options – a synopsis of these methods of evaluation is mentioned, including their advantages and disadvantages.

Lymphoid tissue of the head and neck

Lymphoid tissue in the head and neck is arranged as two horizontal rings and two vertical chains. The rings are called the Waldeyer rings, inner and outer. The outer or superficial Waldeyer ring comprises the occipital, mastoid, parotid, preauricular, facial, submaxillary, sublingual, submental and retropharyngeal lymph nodes. The inner ring is formed by mucosa-associated lymphoid tissue of the nasopharynx and oropharynx. This includes the adenoids posterosuperiorly, the lateral pharyngeal bands and palatine tonsils laterally, and the lingual tonsils anteriorly.[1]

Outer Waldeyer ring

The outer Waldeyer ring is formed by the occipital, mastoid, parotid, preauricular, facial, submaxillary, submental, sublingual and retropharyngeal nodes.

The occipital nodes are related to the occipital artery and vein and the greater occipital nerve in the occipital triangle. This drains the occipital region. The mastoid nodes are located in the postauricular and mastoid tip regions. They drain the skin of the pinna and the parietal scalp. The parotid group of nodes is located in relation to the parotidomasseteric fascia. The pretragal nodes lie above the fascia, while the preauricular nodes lie below it. There are deep nodes which lie within the parotid gland also. These collectively drain the frontoparietal scalp, parotid gland, upper lip, buccal skin and buccal mucosa. The facial nodes lie along the distribution of the facial artery and vein that drain the frontal scalp, skin of the forehead and nose, eyelids, the nasal septum, upper and lower jaws, lips, palate, parotid gland and buccal space. The

submaxillary nodes receive efferents from the parotid and facial nodes. The submental nodes within the submental triangle receive drainage from the chin, anterior part of the lower alveolus, lower lip, floor of the mouth, and the tip of the tongue. The sublingual nodes lie near the sublingual glands and the anterior part of Wharton's duct. They drain the floor of the mouth, the ventral surface of the tongue, and the anterior mandible.[2]

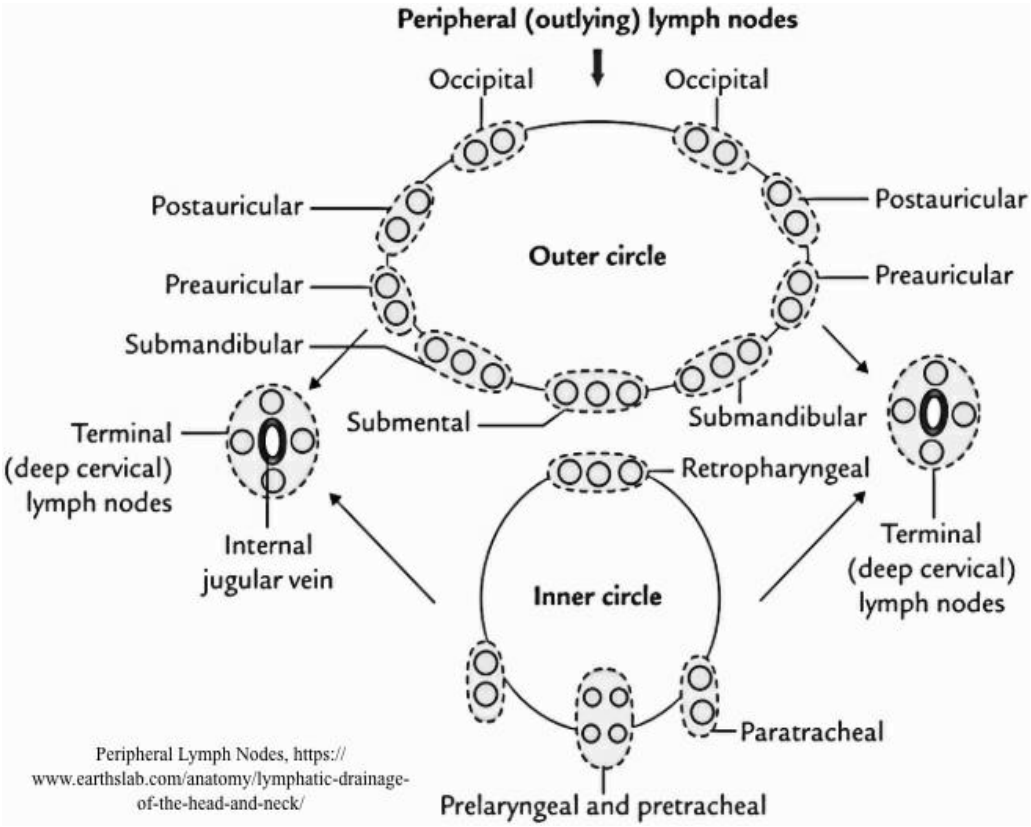


Figure 1: Arrangement of lymphoid tissue in the head and neck region

The retropharyngeal nodes lie between the pharyngeal wall (with the buccopharyngeal fascia) and the prevertebral fascia. Due to their location, they cannot be diagnosed clinically and require imaging for assessment. There are two groups present bilaterally, medial and lateral. The superior-most node of the lateral group is the eponymous node of Rouvier. The medial group of nodes is also known as the node of

Henle. The lateral group of nodes is usually present between the skull base and the C2 vertebra, while the medial group of nodes is seen between the C2 and C3 vertebrae. These nodes are seen prominently in childhood, and they are unusual in adults. The nodes involute between 6-12 years of age, however they may be present on cross-sectional tomography even in older people and may be confused for other structures.[3] When picked up on cross-sectional imaging, the lateral group of nodes are usually seen bilaterally. The medial nodes are rarely seen in isolation - they are usually associated with the lateral group.[4] They drain the nasal cavity, paranasal sinuses, nasopharynx, oropharynx and palate, and middle ear. Retropharyngeal nodes can get infected during upper respiratory tract infections in children, including with pharyngitis, adenotonsillitis, and sinusitis. This can lead to the formation of a retropharyngeal abscess in children. Such primary retropharyngeal abscesses are not seen in children above the age of 5-6 years as the retropharyngeal nodes usually involute by then. When infected, the nodes go through the stages of adenitis and periadenitis, and finally form an abscess. Retropharyngeal abscesses usually present with fever, neck pain, sore throat, dysphagia, drooling, torticollis, and respiratory distress.[5] Examination of the oropharynx may show a swelling in the midline or to one side of the midline of the posterior pharyngeal wall. The diagnosis can be confirmed by a lateral X-ray of the neck or by computed tomography, which will show an increase in the width of the pre-vertebral soft tissue and air-fluid level in the retropharyngeal soft tissue shadow if an abscess is present. Loss of cervical lordosis can also be noted on imaging. The abscess requires intravenous antibiotics and may require surgical drainage, either by the trans-oral or the cervical route.[6] An interesting

association has been noted between adenotonsillar hypertrophy with retropharyngeal nodal enlargement and obstructive sleep apnoea in children - whether the retropharyngeal nodal enlargement contributes to the sleep apnoea or is part of a global lymphoid derangement seen in adenotonsillar hypertrophy remains to be verified.[7]

Collectively, these different nodal groups drain into the spinal accessory, upper jugular, and partly lower jugular nodes. The submental, sublingual and retropharyngeal nodes drain bilaterally.

Lymphatics of the neck

The lymphatics of the neck are arranged in two chains, the superficial and the deep. The superficial chain lies in relation to the external jugular vein while the deep chain is related to the internal jugular vein. The superficial cervical nodes can be further subdivided into the anterior group, which lies close to the anterior jugular vein, and the posterior-lateral group, which lies close to the external jugular vein proper. The deep cervical nodes constitute up to eighty percent of cervical lymph nodes. They are divided into the upper, middle and lower jugular nodes. The upper jugular nodes extend along the superior part of the internal jugular vein, from the skull base till the carotid bifurcation. This group contains the jugulodigastric node. The middle jugular nodes lie between the carotid bifurcation and the omohyoid tendon at the level where it crosses the internal jugular vein. The lower jugular nodes extend from the omohyoid tendon down till the thoracic inlet.

Other than the jugular nodes, other groups, which form a part of deep cervical lymphatics, include two transverse chains – one extending along the spinal accessory nerve and the other along the transverse cervical artery. Also included are the juxtavisceral nodes, which comprise the prelaryngeal, prethyroid, pretracheal and paratracheal nodes. The superficial cervical nodes drain into the deep jugular nodes, and ultimately into the thoracic duct on the left and the right lymphatic duct on the right.

Inner Waldeyer ring

This consists of the submucosal lymphoid tissue aggregates spread around the orifices of the pharynx. They include the palatine tonsils, lingual tonsils, tubal tonsils, adenoids, and lateral pharyngeal bands.

The palatine tonsils are situated in the oropharynx on either side between the folds formed by the palatoglossus and palatopharyngeus muscles.

The adenoids or pharyngeal tonsils comprise the lymphoid tissue on the roof and posterosuperior wall of the nasopharynx.

The tubal tonsils lie in relation to the pharyngeal opening of the Eustachian tube. They are also known as Gerlach's tonsils and lay inferolaterally in relation to the adenoids.

The lingual tonsils are formed from lymphoid tissue lying within the posterior one-third of the dorsum of the tongue.

The lateral pharyngeal bands are formed by lymphoid tissue extending along the

posterior tonsillar pillar (palatopharyngeal arch) and behind the soft palate.

These lymphoid tissue aggregates encounter both air-borne and alimentary antigens and thus participate in local and humoral immunity.[8]

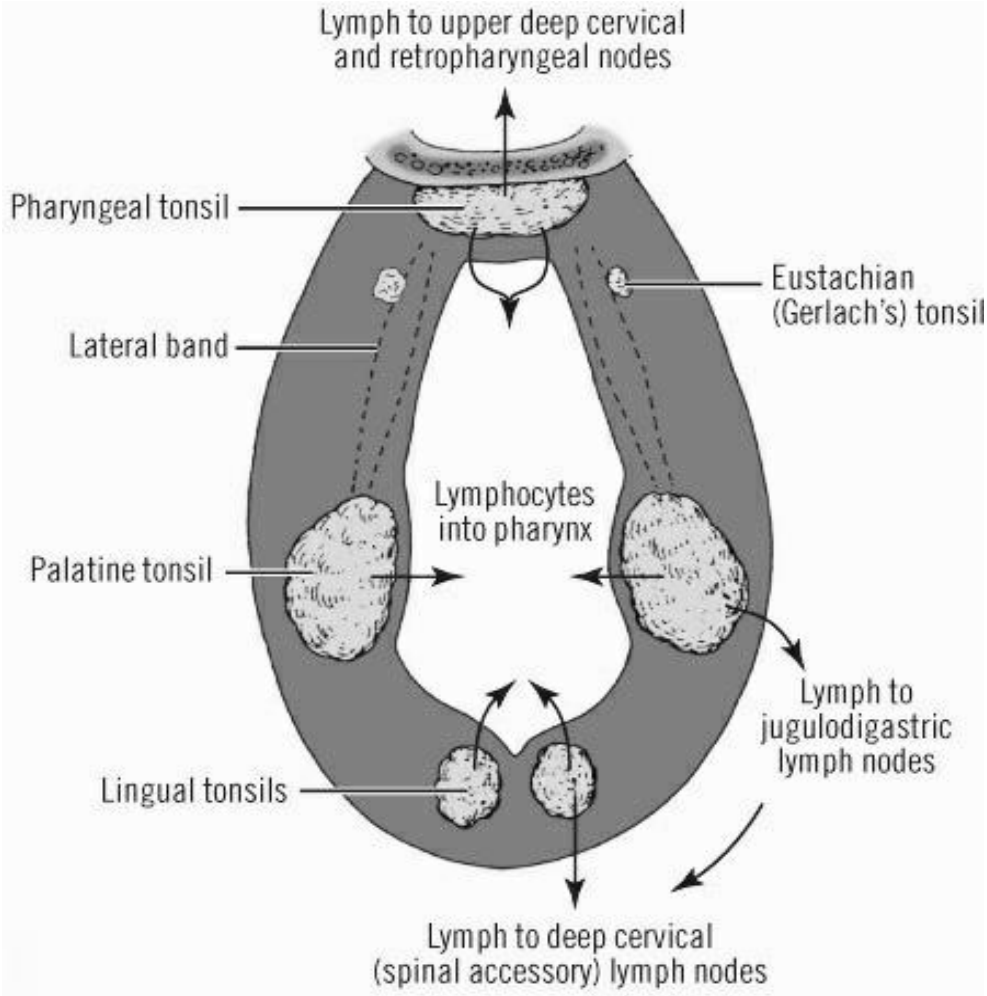


Figure 2: Diagrammatic illustration of the inner Waldeyer ring

Adenoids and nasopharynx

The nasopharynx is the uppermost part of the pharynx. It extends from the base of the skull superiorly to a plane passing through the hard palate inferiorly. It is bounded anteriorly by the posterior part of the nasal septum and the choanae. Superiorly and posteriorly, the walls are continuous and are formed by the lower part of the body of the sphenoid, the basilar part of the occipital bone, and the arch of the atlas lower down, with the prevertebral muscles and fascia, superior constrictor, pharyngobasilar fascia and mucosa overlying it. Inferiorly, the nasal surface of the soft palate forms a mobile boundary, apposing posteriorly with the palatopharyngeal fold (also known as Passavant's ridge), with the nasopharyngeal isthmus lying between the two and connecting the nasopharynx to the oropharynx. Because of the mainly bony walls of the nasopharynx (except inferiorly), the nasopharyngeal walls do not collapse due to muscle action unlike in the oropharynx and hypopharynx.

The lateral wall of the nasopharynx has the pharyngeal openings of the Eustachian tube on each side, formed by tubal cartilage. The salpingopharyngeus muscle and the overlying salpingopharyngeal fold descend from the posterior limb of the tubal cartilage. A smaller, less pronounced, salpingopalatal fold extends from the anterosuperior part of the tubal opening to the soft palate anteriorly. The tubal tonsil is found in the mucosa immediately behind the opening of the Eustachian tube. The Fossa of Rosenmuller, also known as the lateral pharyngeal recess, is located between the posterior pharyngeal wall and the salpinopharyngeal fold. It overlies the cartilaginous covering over the foramen lacerum and the internal carotid artery.[9] It is a common site for nasopharyngeal carcinoma.

The nasopharyngeal bursa is a median recess within the pharyngeal tonsils, which represents the embryological attachment of the notochord to the pharyngeal endoderm. It extends from the mucosa of the pharyngeal tonsil to the periosteum of the occipital bone. Thornwaldt's disease is a condition where an abscess forms in the nasopharyngeal bursa.[10]

The Rathke's pouch is represented by a dimple above the adenoids. Embryologically, it forms the anterior lobe of the pituitary gland.[11]

Between the base of the skull and the upper free border of the superior constrictor lies the sinus of Morgagni, through which passes the Eustachian tube, the levator veli palatini muscle, the tensor veli palatini muscle, and the ascending palatine branch of the facial artery.[12]

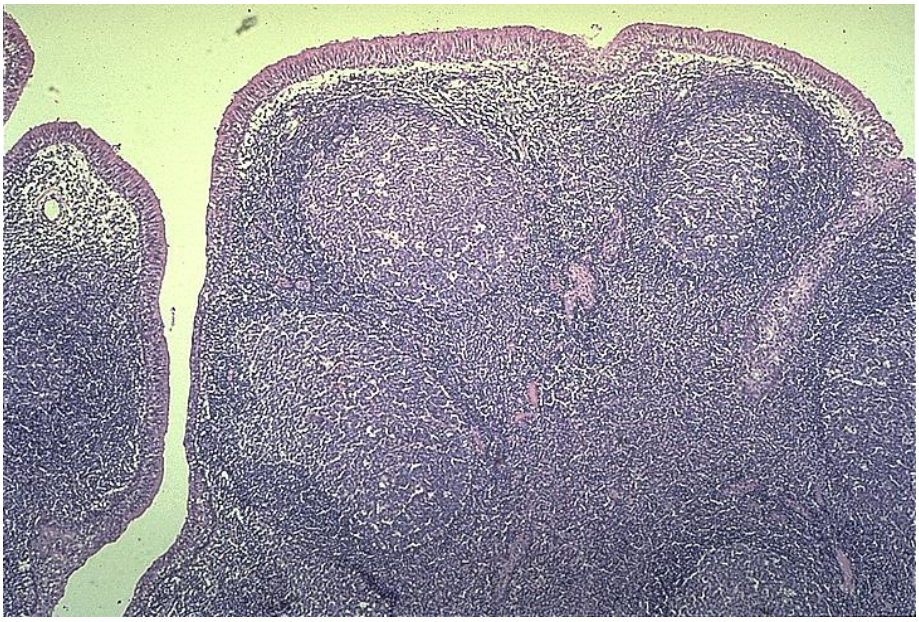
The nasopharynx is lined by pseudostratified ciliated columnar epithelium as a continuation of the nasal epithelium. It changes to non-keratinized stratified squamous epithelium in the posteroinferior part, which continues into the oropharynx.

The nasopharynx is innervated mainly by the pharyngeal branch of the pterygopalatine ganglion, which passes through the palatovaginal canal.

The nasopharynx primarily drains into the retropharyngeal lymph nodes, and into the upper deep cervical nodes and the spinal accessory chain of nodes in the posterior triangle.[13]

The adenoids lie on the posterosuperior wall of the nasopharynx. It comprises the mucosa-associated lymphoid tissue that forms the central part of the inner Waldeyer ring. Mucosa-associated lymphoid tissue, or MALT, contains a significant number of

lymphocytes.[14] The adenoids have four anatomic regions - the epithelium, the mantle zone, the follicular germinal centre and the interfollicular area.



Courtesy of www1.udel.edu/biology/Wags/histopage/colorpage/cly/cly.htm

Figure 3: Histology of the pharyngeal tonsil

The adenoids have lymphocytes distributed in the epithelium and in the subepithelial areas. Discrete follicles or nodules of lymphoid cells are found in the lamina propria and submucosa. Most of these aggregates lack a capsule. Also found in these aggregates are type III collagen fibres and fibroblasts. The lymphocytes are mainly B cells (approximately 65%), with the rest composed of T cells (30%) and macrophages (5%).[15] The T cells are predominantly CD4 positive. The B cells are found mainly in the germinal centres, while the T cells are distributed in the interfollicular areas. Adenoids have cells secreting immunoglobulins A, M and G. Cells secreting IgG are more common than cells secreting IgA and IgM.[16,17] Because of the close proximity of the lymphocytes to the surface epithelium, the lymphocytes are easily exposed to inhaled or ingested antigens. The epithelium overlying the MALT contains modified

stratified squamous reticulated cells (microfold cells) and dendritic cells that help in sampling and transferring antigens to the antigen-presenting cells within the MALT. B cells and T cells undergo activation and proliferation in the MALT tissue, and these activated cells are dispersed along the regional lymph nodes to provide immunity. B cells also disseminate to the mucosa of the nose and upper airway, and to the salivary and lacrimal glands. The B lymphocytes produce IgA which is secreted into the lumen.[18,19]

The adenoids receive blood supply from branches of the external carotid artery, including the ascending pharyngeal artery, from branches of the facial artery like the ascending palatine and tonsillar branches, from branches of the maxillary artery such as the pharyngeal branches and the vidian branch, and the basisphenoid artery. Veins drain into the internal jugular and facial veins via the pharyngeal plexus and the pterygoid plexus of veins. The nerve supply of the adenoids is from the pharyngeal plexus – the sensory supply is by the branches of the glossopharyngeal nerve and the motor supply is by the branches of the vagus nerve. Lymphatics drain into the retropharyngeal lymph nodes, and from there into the deep cervical lymph nodes. Lymph also drains into the pharyngomaxillary lymph nodes.

Adenoids are colonised by a variety of micro-organisms, including Gram positive and Gram negative organisms, both aerobes and anaerobes. The commonest organisms include *Streptococcus* species, *Staphylococcus* species, *Haemophilus influenzae*, *Moraxella catarrhalis*, and *Prevotella* and *Fusobacterium* species. The same organisms could also be found in diseased adenoids, however in much higher concentrations (100-1000 fold higher).[20]

Growth pattern of adenoids

Adenoids begin to develop by the 3rd month of fetal development. In the posterior nasopharynx, glandular primordia form by the fourth month of fetal development, and lymphocytes infiltrate into these primordia.[21] Crypts begin to form by the fifth month of fetal development. Pseudostratified ciliated epithelium covers the adenoids. The adenoids are completely formed by the seventh month.

The adenoids usually start increasing in size at 4 years of age, and gradually progress to reach maximum volume between 7-8 years of age. Following this, it gradually decreases in size.[22] They may be present earlier, from about 3-4 months of age.[23] The nasopharyngeal volume, in contrast, grows slower than the adenoids between the ages of 2 and 5 years, but catches up by 7-8 years and gradually overtakes the growth rate of the adenoids.[24] This is usually due to the displacement of the hard palate downward, which increases the nasopharyngeal height from the sphenoid bone to the palate.[25,26] The transverse width of the nasopharynx increases more between 8-10 years of age, while the vertical growth is more between 12-13 years of age.[27] Thus, between 4 and 7 years of age, the mismatch between adenoid growth and nasopharyngeal expansion can cause symptoms of nasopharyngeal obstruction, which gradually improves as the child grows older.

Adenoid hypertrophy – definition and causes

Adenoid hypertrophy refers to the enlargement of the pharyngeal tonsils due to any cause. Commonly, it is due to a mismatch between the adenoid volume and the nasopharyngeal volume as the patient grows. It can occur due to infection, either viral or bacterial, when it will be associated with signs of inflammation like congestion of the nasopharynx with discharge. Common viral pathogens include Adenovirus, Rhinovirus, and Paramyxovirus. Epstein-Barr virus may also be a causative factor. Bacteria causing adenoid infection include *Haemophilus influenzae,* group A beta hemolytic *Streptococcus, Staphylococcus aureus, Moraxella catarrhalis*, and *Streptococcus pneumoniae*.[28] Several congenital disorders can lead to enlargement of the adenoids due to accumulation of various materials in the substance of the adenoids. An example of this is the mucopolysaccharidoses, a group of conditions where glycosaminoglycans are not degraded due to deficiency of various lysosomal enzymes, and thus get deposited in several areas of the body including the adenoids.[29] Midface and other developmental anomalies can also affect the ratio between adenoid volume and nasopharyngeal volume and cause symptoms.

In recent studies, surface colonization of the adenoids by various bacteria with biofilm formation has been implicated in persistent infection and associated complications. The commonest organisms found in the adenoids with strong predilection for biofilm formation are *Streptococcus pneumoniae, Moraxella catarrhalis, Haemophilus influenzae* and *Staphylococcus aureus*.[30] A biofilm is a colony of microbes that is irreversibly attached to a surface and enclosed within an extracellular polymeric matrix. The extracellular polymeric matrix is composed of polysaccharides, proteins,

water, and DNA.[31] There is a well-defined architecture with porous areas for water transport and cell clumps without pores. In addition to the switch from planktonic mode to sessile mode, such bacteria also show more resistant phenotypes due to activation of stress genes in response to cell density and other environmental parameters. All these combine to give the microbes a survival advantage. The biofilm also protects the microbes from the effects of antibiotics. This is by several mechanisms, including decreased antibiotic penetration due to the polymeric matrix, accumulation of enzymes that can degrade or inactivate the antibiotics in the glycocalyx, slow growth rate of cells (especially in the interior of the biofilm), presence of persistent cells which are more resistant to stress and antibiotics, the presence of efflux pumps which decrease the local concentration of antibiotics, low permeability of bacterial outer membranes by the alteration of membrane porin proteins, and phase variation such as the small colony variants (present in the quiescent state) which are relatively resistant to growth phase dependent killing by antibiotics.[32] Biofilms have been shown to exist on the folds and in the crypt-like areas between the folds of adenoids. The films in the areas of mucociliary clearance were usually found on the top of the folds, while those in areas away from the mucociliary clearance pathways were found between the folds also.[33] Biofilm-producing microbes can invade epithelial cells and form intra-cellular biofilms. This has been demonstrated in the adenoid tissue of patients who underwent adenoidectomy for obstructive sleep apnoea and chronic otitis media. Studies have shown that there are more biofilm-forming *Haemophilus influenzae* cell aggregates in adenoids from children with chronic otitis media and otitis media with effusion as

compared to adenoids from children with obstructive sleep apnoea. A similar association has also been noted with *Staphylococcus aureus* and adenoids in children with chronic rhinosinusitis.[34] Thus, biofilm formation has been implicated in recurrent acute otitis media associated with adenoid hypertrophy, as well as persistent sinusitis, and recurrent tonsillitis even after surgery. As well as interfering with antibiotic penetration; the microbial films spread along the mucosal surfaces to transmit infection to nearby structures. Thus, surgery is very often needed to disrupt the biofilms and help in better antibiotic efficacy and improvement in symptoms.

Allergy has been found to be associated with adenoid hypertrophy. Due to the position of the adenoids, they are constantly exposed to allergens via the nasal and oral route. This can predispose to an abnormal immune response and the onset of atopy. In allergic adenoiditis, there is an increase in the number of mast cells seen in the adenoids, as well as a class switch in the immunoglobulins produced, with more IgE being produced and IgE levels being elevated. Seasonal allergen exposure may be associated with intermittent worsening of symptoms due to adenoid hypertrophy, while perennial allergic rhinitis causes symptoms around the year.[35]

PFAPA syndrome has also been described in relation to adenoid hypertrophy. It is an acronym standing for "**p**eriodic **f**ever, **a**phthous ulcers, **p**haryngitis and cervical **a**denitis" syndrome. It usually presents in children less than 5 years of age, and clinical and laboratory evaluation is usually inconclusive.[36] It is a diagnosis of exclusion, after ruling out inherited causes. It is diagnosed by the periodicity of the fevers, which respond poorly to antipyretics, and the presence of oral ulcers, throat pain and neck nodal enlargement.[37] It is a self-limiting illness resolving in a few years,

however adenotonsillectomy has been postulated to improve the symptoms dramatically.[38]

Adenoid hypertrophy – symptoms and sequelae

Adenoid hypertrophy is associated with a varied constellation of symptoms. Symptomatic adenoid hypertrophy with larger adenoids is seen in children less than 6-8 years, which is when the nasopharyngeal volume is comparatively less. The mismatch in volume between the adenoids and nasopharynx causes the adenoids to impinge on local structures, thus affecting their function. The features of adenoid hypertrophy include nasal obstruction, breathing through the mouth, snoring, and nasal discharge. Severe obstructive symptoms are associated with sleep-disordered breathing, nocturnal enuresis, apneic episodes during sleep and daytime somnolence.[39] When the adenoids impinge on the posterior choanae, they cause nasal obstruction, with varying degrees of severity. Adenoids interfere with nasal airflow by increasing the nasal resistance to higher levels. When nasal resistance is within the normal limits of 2-3.5 $cmH_2O/L/sec$, the velocity of the inspired air is sufficient to ensure oxygenation of the most distal alveoli of the lungs. However, when nasal resistance increases to such a degree that nasal breathing is uncomfortable and mouth breathing starts, the velocity of inspired air decreases and thus decreases oxygenation of the lungs. This also causes a buildup of carbon dioxide and decreases lung compliance. It can also affect cardiac function. The hypercapnea and hypoxia in blood caused by decreased gas exchange causes respiratory acidosis. This in turn causes

vasoconstriction of the pulmonary artery in response to the hypoxemia and increase in pulmonary artery pressure (WHO Classification for pulmonary hypertension group 3), with consequent increase in the work of the right ventricle, right ventricular hypertrophy, and right heart failure in the long term.[40] The increase in right ventricular filling pressure also pushes the interventricular septum to the left, thus interfering with filling of the left ventricle. Thus long-standing right heart failure can also cause left heart failure.

The adenoids can mechanically impinge on the opening of the Eustachian tube. This leads to build up of negative pressure within the middle ear. Failure to release the negative pressure after a prolonged period causes retraction of the tympanic membrane, accumulation of fluid and secretions within the middle ear causing otitis media with effusion, hearing loss, and can cause formation of secondary acquired cholesteatoma as a long term sequela.[41] Even adenoids that do not seem to obstruct the Eustachian tube can cause problems during swallowing, when they can push the posteromedial wall of the pharyngeal opening of the Eustachian tube laterally and thus prevent opening of the Eustachian tube. This is commonly seen in children with allergic rhinitis, when the mucosa of the torus tubaris may be oedematous. Allergy can also cause oedema of the mucosa of the Eustachian tube, and thus lead to its obstruction. Surfactant is present in the Eustachian tube, which decreases the work of opening the tube and helps in maintaining patency. The presence of bacterial biofilms impairs the action of surfactants, and affects the ventilation of the middle ear, with its consequent effects. It can also cause recurrent acute otitis media due to ascending infection from the nasopharynx.

Adenoiditis also causes recurrent colds, persistent sinusitis[42] and headache, recurrent lower respiratory tract infections, and can act as a reservoir for recurrent tonsillar infection. Adenoid hypertrophy is also seen more commonly in children with allergy and asthma, partly because allergy worsens adenoid hypertrophy, and also because adenoid hypertrophy worsens the symptoms of allergy.

Chronic adenoid hypertrophy affects maxillofacial development, leading to the classical 'adenoid facies'. This comprises a dull look with open mouth, upper lip retraction, crowding of teeth on the maxillary alveolar ridge, increased anterior face height, high palatal arch, change in mandibular and tongue alignment, and dental malocclusion.[43] Mouth-breathers keep their lips open, and the tongue is pressed down; the muscles of the cheek compress the alveolar process of the maxilla and mandible in the region of the pre-molars. There is loss of palatal pressure of the tongue, narrowed palate and face, increase in the inclination of the palate with relation to the skull base, and increase in the height of the lower half of the face, with hypoplasia of the mid-face. Mandibular protrusion can develop due to the tongue being displaced anteriorly and downward, and dental malocclusion can occur.[44] Common dental problems identified in such children include cross-bite, open bite, and retroclined upper and lower incisors.

In the long-term, children affected by interrupted sleep and daytime sleepiness can show poor scholastic performance with missed schooldays and decreased attention spans.[45] The frequent awakenings during sleep causes decreased non-REM (rapid eye movement) sleep, which leads to increased sympathetic tone during sleep, with intermittent increased parasympathetic activity during arousals (when hypoxaemia

worsens), and persistent increase in sympathetic activity while awake. This causes reduced heart rate variability. Intermittent hypoxaemia is also associated with oxidative stress and increased arrhythmogenicity. All these contribute to the cardiovascular co-morbidities and neurological impairments associated with severe sleep-disordered breathing.

Treatment methods

Treatment options for symptomatic adenoid enlargement include both medical and surgical management. Medical management includes use of topical intranasal corticosteroids, intranasal antihistamines, topical hyaluronic acid sprays, and oral antileukotrienes. Surgical treatment includes adenoidectomy by various methods.

Intranasal corticosteroids have been well studied in the management of allergic and obstructive symptoms due to adenoid hypertrophy. This is on the basis of the presence of raised levels of inflammatory mediators in adenoid tissue, along with an increased number of steroid receptors. In atopic individuals, IgE antibodies bind to receptors on mast cells. When allergens bind to these antibodies, they trigger degranulation of mast cells and release of inflammatory mediators. These act on the mucosa to cause sneezing, nasal discharge and nasal congestion. The main mediators involved in this acute phase reaction are histamine and arachidonic acid metabolites including leukotrienes. The late phase allergic reaction, which occurs due to the influx of monocytes, eosinophils, basophils and T lymphocytes, is characterized by the release of interleukins, interferons, tumor necrosis factor alpha and other inflammatory

proteins. These continue to stimulate the nasal mucosa and cause allergic symptoms.[46,47] Steroids act by activating the glucocorticoid receptor. Glucocorticoid receptor is present in the cytoplasm in its inactive form. Binding of the steroid molecule to the glucocorticoid receptor activates it, and causes it to translocate into the nucleus, where it modulates gene expression and causes down-regulation of cytokine production and reduction in inflammation.[48] Clinical studies have been done using mometasone, beclomethasone, fluticasone and flunisolide.[49] The studies have shown a significant improvement in symptoms and steroid size in obstructive symptoms due to moderate to severe adenoid hypertrophy, sometimes significant enough to avoid surgery.[50] The response is not always correlated to the presence of atopy as conflicting studies have shown. Short term efficacy has been studied, however the long term effects are being explored. Children often need maintenance therapy to maintain the response[51], and may still require surgery for worsening symptoms or ear symptoms.[52] The advantages of nasal steroids include the ease of application and the decreased systemic absorption and hence reduced systemic side effects. The main side effects of nasal steroids include epistaxis, dryness and crusting in the nose, and candidiasis.[53] In terms of efficacy in symptom control especially of allergic symptoms, fluticasone propionate and mometasonefuroate have been demonstrated to be the most effective, followed by budesonide and flunisolide.[54,55]

Antihistamines have been tried in the treatment of adenoid hypertrophy. In chronic adenoiditis, there is an increase in the number of mast cells in the adenoids.[56] The presence of allergy and mast cell degranulation causes an increase in histamine and other inflammatory mediators in the mucosa. Prostaglandins and leukotrienes cause an

increase in the mucosal secretions and mucosal oedema. Histamine also induces oedema of the Eustachian tube and with consequent otitis media with effusion.[57]Azelastine is the most commonly studied intranasal antihistamine. It is a relatively selective H1 receptor antagonist that inhibits the release of histamine from inflammatory cells.[58] It also has some action in inhibiting other mediators like leukotrienes and platelet activating factor. It has a role in mast cell stabilization. It may also interfere with the accumulation of eosinophils at sites of allergy, and prevent their degranulation there. Thus it helps in controlling allergic symptoms, especially those of nasal discharge and obstruction, cough and snoring in children with adenoid hypertrophy.[59] Its efficacy in controlling allergic symptoms has been shown to improve when it is administered in combination with intranasal corticosteroids like fluticasone.[60] Levocabastine and olopatadine are the other intranasal antihistamine preparations, however their effect has not been studied in adenoid hypertrophy. Oral antihistamines have been used for the same reason, with improvement in nasal congestion and rhinorrhoea, although intranasal corticosteroids are more effective. If used, second generation antihistamines like cetirizine, levocetirizine and fexofenadine are preferred to the older antihistamines.[61]

Mast cell stabilizers have been tried as oral and intranasal preparations in the treatment of allergic rhinitis - it has not been studied in adenoid hypertrophy. The common drugs in this class are disodium cromoglycate and nedocromil sodium. They have a role in blocking late-phase allergic responses and acquired hyper-reactivity by its influence on calcium channel receptor opening.[62] However there is heterogeneity in the response to mast cell inhibitors which means that the compounds may not always

work effectively in the treatment of allergic symptoms. This may be due to other pathophysiological mechanisms involved in the production of allergic symptoms which are not addressed by these drugs.[63] Intranasal cromones may help in reducing sneezing, rhinorrhoea, nasal obstruction and nasal itch[64], however they are less effective compared to intranasal corticosteroids and antihistamines.[65] They also need to be taken frequently and thus, compliance may be an issue.

Anti-leukotrienes are another useful group of drugs in the treatment of allergy. They are of two classes, leukotriene-related enzyme inhibitors and leukotriene receptor antagonists. **Leukotriene-related enzyme inhibitors** inhibit the arachidonate 5-lipoxygenase enzyme, an example of which is the drug zileuton. **Leukotriene receptor antagonists** block cysteinyl leukotriene receptors and include montelukast and zafirlukast.[66] Cysteinyl leukotriene receptor-1 has been shown to be increased in the adenoids and tonsils of children with adenoid hypertrophy and obstructive sleep apnoea. Montelukast has been studied in adenoid hypertrophy, and has been shown to decrease the severity of snoring, mouth breathing and disturbed sleep in children with adenoid hypertrophy. It also helps in decreasing the size of the adenoids, and this improvement may be more marked in patients with smaller adenoids, especially if intended to delay or avoid surgery.[67,68]

Hyaluronic acid is a high molecular weight glycosaminoglycan that is found in the extracellular matrix of nasal and tracheobronchial mucosa, airway secretions and serous cells in glands. It helps in the lubrication of epithelial surfaces, and is postulated to modulate airway inflammation by regulating the movement and accumulation of polymorphonuclear leukocytes and monocytes. It also helps in

mucociliary clearance, promotes phagocytosis of pathogenic micro-organisms, and helps in preventing microbial adhesion and biofilm formation. Nasal douche with hyaluronic acid has been shown to cause a significant moderate decrease in adenoid size with improvement in patency of the Eustachian tube orifice, and decrease in the number of episodes of acute otitis media in children with adenoid hypertrophy.[69,70] It is useful as an adjunctive therapy in the treatment of adenoid hypertrophy.

Adenoidectomy

Surgery has been the mainstay in the treatment of adenoid hypertrophy. Indications for adenoidectomy may be classified as infective or obstructive. Infective indications include recurrent colds and sinusitis, recurrent pharyngitis and tonsillitis, recurrent acute otitis media, and recurrent ear discharge in chronic otitis media. Obstructive indications include sleep disordered breathing, obstructive sleep apnoea[71], Eustachian tube obstruction causing otitis media with effusion and hearing loss, disorders of speech like rhinolalia clausa, and dental malocclusion.[72] The surgery may or may not be combined with tonsillectomy, myringotomy with or without grommet insertion, and tympanoplasty with or without mastoidectomy.

Adenoidectomy is contraindicated in the presence of cleft palate or submucosal cleft palate, due to the risk of velopharyngeal insufficiency.[73] Care should also be taken in children with Down's syndrome due to the risk of atlanto-occipital instability.[74] The presence of coagulation disorders is a relative contra-indication, since post-operative bleeding complications do not always occur with pre-operative derangement in

coagulation profiles[75], and the use of newer techniques like suction diathermy and coblation and radiofrequency ablation decreases the incidence of intra-operative bleeding. Pre-operative haemostatic work up is essential in the presence of history suggestive of bleeding disorders either in the patient or the patient's family.[76]

There are several methods of adenoidectomy, classified as 'hot' and 'cold' methods. Cold methods include using adenoid curette or adenotome. With the advent of powered instrumentation, other methods of removal using microdebrider, and powered shaver with both cutting and suction actions, have been used. Hot methods include using suction diathermy, coblation and radiofrequency ablation.

All methods involve shaving or removing the adenoid tissue off the posterosuperior nasopharyngeal wall and from the Eustachian tube openings, either as a blind procedure (when using adenoid curette or adenotome), or under vision using endoscope or posterior nasal mirror (with all methods of adenoidectomy). The patient is positioned in Rose's position - the head is extended at the atlanto-occipital joint, and the neck is extended on the chest by placing a roll below the shoulders. The procedure is done under general anaesthesia.

The La Force adenotome used is an 18 mm wide instrument with a box at one end. It is inserted through the oral cavity and the adenoids are engaged in the box, following which the box is closed. The box traps the adenoid tissue and removes it. This is a blind procedure. Adenoid remnants are not easily removed using the adenotome.

The St. Claire Thomson adenoid curette is an instrument which is available in a number of sizes. The tip of the instrument is square, curved and fenestrated, with a

sharp inner blade. Other variations of the instrument are also available. It is inserted similar to the adenotome through the oral cavity into the nasopharynx. The tip of the blade hitches on the adenoid tissue and engages it, and the sharp inner blade helps to scrape off the adenoid tissue from the posterior pharyngeal wall. A smaller blade can be used to remove remnant tissue in the choanae and on the lateral walls of the nasopharynx near the torus tubaris. Even though the procedure is started with the patient in Rose's position, care has to be taken to flex the head after the adenoid curette is positioned, just before scraping the tissue off. This is to protect the odontoid process of the axis vertebra from injury. The adenoid curette can be used under endoscopic vision with better results, as all the remnant adenoid tags (usually in the choanae and along the posterior border of septum) can be engaged and removed under vision without damage to the surrounding structures.

The microdebrider is an instrument composed of a hollow metal tube with a blade, a handpiece with suction, and a console with a foot pedal to control it. The blade has a port to allow suction to act, thus pulling in tissue into the blade's aperture and cutting it. The suction also removes blood and cut tissue from the operating field. Blades of different sizes and angulation are available. The speed of the blade and the direction of rotation can be controlled by the console and the foot pedal. The microdebrider is used under vision, either with rigid endoscopes transnasally or using laryngeal mirrors to provide vision during debridement. It is usually safe, except for the danger of sucking and cutting normal tissue. However, with proper handling and direction of the debrider tip, this risk can be minimized.[77]

Suction diathermy or electrocautery uses a current passed through a metal electrode

with consequent heat generation. This heat helps in destroying tissue and in haemostasis. The instrument used has a hollow centre to suction blood and smoke from the field. The current is passed through the metal rim - when applied to the adenoid tissue, it shrinks, and can be curetted out or left to fall off later. There is a risk of nasopharyngeal scarring and choanal stenosis if the cautery tip is applied to the normal tissue of the nasopharynx, like the Eustachian tube openings, the choanal borders including the posterior border of the septum, roof and floor of the choanae. The suction diathermy method is always used under visualization either with an endoscope or a laryngeal mirror, and helps in addressing hard to reach areas like the choanae. Blood loss during surgery is also reduced with this method. The rates of regrowth were comparable to conventional adenoid curettage.[78]

Radiofrequency ablation was done by applying high frequency radiowaves onto tissue causing an ionic agitation of the surrounding tissues, with separation of tissue. On comparison with conventional adenoidectomy, radiofrequency ablation method had improved immediate post-operative recovery, with less pain, improved oral food intake, and less dehydration. However, there was an increased risk of delayed secondary haemorrhage. Long-term recurrence rates were comparable to conventional curettage. The other drawbacks with this method were the cost of the instruments and the learning curve to use the system.[79]

Coblation adenoidectomy or radiofrequency ionization or plasma-mediated ablation uses a variation of radiofrequency ablation where saline is continuously irrigated into the surgical field. The radiofrequency waves cause ionization of the saline and formation of plasma containing high-energy particles which can dissolve tissue.[80] The

temperatures achieved were lower than that in radiofrequency ablation, with consequent decrease in thermal damage to surrounding tissue. It had the same advantages as radiofrequency ablation, with the same risk of post-operative haemorrhage and recurrence as conventional adenoidectomy.[81] The expense associated with the system was a drawback.[82]

Adenoidectomy is usually a simple procedure. Intra-operatively, the use of the mouth gag can cause complications during surgery including avulsion of teeth and temporomandibular joint dislocation or fracture of the mandibular condyle. It can also be associated with accidental withdrawal of the endotracheal tube and kinking of the tube.[83] These complications can be avoided by careful positioning and technique. In the immediate post-operative period, patients often have pain in the throat or ears and fever. The main complications include bleeding (primary or secondary), velopharyngeal insufficiency, injury to the Eustachian tube opening, nasopharyngeal stenosis, and rarely atlanto-occipital dislocation and Grisel syndrome (neck pain and torticollis due to paraspinal muscle spasm or atlanto-occipital dislocation).[84]Atlanto-occipital instability is more common in children with Down's syndrome[85] and mucopolysaccharidoses. Aspiration is also a possibility, either during surgery due to displacement of the endotracheal tube, or due to unrecognized haemorrhage which can cause the patient to swallow blood, especially while still recovering from anaesthesia. The most significant operative complication is bleeding. Bleeding may be immediate (recognized intra-operative or within twenty four hours of surgery), or delayed. Delayed haemorrhage occurs due to premature clot separation – this may be precipitated by infection or dehydration. Velopharyngeal insufficiency is usually seen

in patients with a cleft palate (obvious or submucosal) or other palatal abnormality. Long term, there is a risk of recurrence of adenoid hypertrophy, especially in case of incomplete excision.

Evaluation of adenoids

The major difficulty with evaluation of adenoids is its position, which makes it hard to assess clinically. Also, the adenoid volume needs to be assessed in relation to the nasopharyngeal volume in order to correlate well with its symptomatology. Some form of imaging or invasive testing is needed to ascertain its size. The investigations used include the following:

- Lateral radiography of the skull
- Acoustic rhinometry and rhinomanometry
- Posterior rhinoscopy
- Video fluoroscopy
- Endoscopic evaluation

Lateral radiography of the skull

Lateral radiography of the skull may be lateral cavum (nasopharyngeal X-rays), or lateral cephalometric X-rays. For lateral cephalometric X-ray, or lateral cephalogram, is a standardized sagittal view X-ray of the skull, taken using Broadbent's standards. The position of the head is fixed using a cephalostat or craniostat. The craniostat has two Perspex arms with an ear piece or rod attached, which is inserted into the patient's external auditory canal, thus immobilizing the head. The sagittal plane of the patient's

head should be vertical and parallel to the cassette. The horizontal plane of Frankfurt (a plane passing through the inferior borders of the bony orbits and the upper margins of the external auditory meatus) should be parallel to the floor. The ear pieces contain metal markers, which are aligned and superimposed to ensure proper centering. The patient is made to close the mouth and bite, breathe gently through the nose, and keep the lips relaxed. The X-ray beam is centred on the external auditory meatus of the patient with the help of the metal ear pieces as guidelines. The X-ray beam is collimated so that the region of the skull above the orbits and the lower part of the cervical spine is protected from radiation. The film is placed at a distance of 150 to 200 cm from the X-ray source. The lateral cephalometric X-rays are usually ordered in dentistry, and makes use of several reference points in the bone and soft tissue. These reference points can be manually or digitally recorded and analysed.[86] The cavum X-ray or lateral nasopharyngeal X-ray is mainly used by otolaryngologists, and does not use fixed head positioning, with the central beam of X-rays being directed to the nasopharynx. Thus there is a chance of movement artefacts. The interpretation is subjective as head position is not fixed. However, this leads to simpler analysis of the adenoid size and is easy to use in clinical application. The lateral cephalometric and nasopharyngeal X-rays have been compared for use in assessing adenoid hypertrophy. While lateral cephalometric X-rays were good for assessing the size of the adenoids, the assessment of nasopharyngeal airway was not as good as in lateral nasopharyngeal X-ray. This was attributed to the fact that the adenoid, being a simpler three dimensional structure than the nasopharynx, was more faithfully shown in the two dimensional X-rays.[87] However, other studies have shown equivalence between the

lateral cephalometric and nasopharyngeal X-rays.[88,89]

Acoustic rhinometry and rhinomanometry

Acoustic rhinometry is a non-invasive test that assesses the cross-sectional area of the nose using acoustic measurements based on the distance from the nostril. Patient cooperation required for the procedure is minimal and the test can be easily performed in children without sedation. Sound waves travelling through the nose are reflected by the various anatomical structures - the time taken for these reflections is a measure of the distance the waves travelled in the nose and helps in identifying the location of the obstruction. Rhinometry helps in measuring nasal volume, but is accurate only for the initial 5-6 cm from the nostrils (till the mid-posterior end of the middle turbinate). Thus the nasopharyngeal volume cannot be measured accurately.

Rhinomanometry is the gold standard test for measurement of nasal airway resistance. This is calculated from two values - the nasal air flow and the trans-nasal airway pressure. Rhinomanometry can be active or passive, anterior or posterior or post-nasal. In anterior rhinomanometry, the pressure transducer is placed at the opening of the nostril that is not being tested. In posterior rhinomanometry, the transducer is kept at the posterior oropharynx. In the post-nasal method, the transducer is placed in one of the posterior choanae. The active technique implies that the patient breathes through one nostril while the pressure is measured in the other nasal cavity. In the passive technique, a steady flow of air is passed through each nasal cavity while the patient holds his breath and the pressure is measured separately for each side. Anterior rhinomanometry may be active or passive, while posterior rhinomanometry is usually

done with the active method. The method of choice according to the International Committee on Standardisation of Rhinomanometry (ICSR) is the active anterior method using a face mask with adhesive tape used to occlude the nasal vestibule (the tape does not deform the vestibule). Active anterior rhinomanometry has the advantage of being a relatively rapid procedure, with graphic registration. However, it cannot be done in patients with septal perforation, and only one nostril can be recorded at a time. The mask or nasal pieces used can also interfere with the test. Passive anterior rhinomanometry can be used even if one nostril is obstructed and also gives a graphic representation, however it is expensive and patients may not always be able to cooperate in maintaining apnoea during the test. It can be used as a screening tool for larger groups. In posterior rhinomanometry, nasal deformation is avoided and total nasal resistance can be measured even in the presence of septal perforation, however it is time-consuming and the two nostrils cannot be studied separately. It can be used in patients with septal perforation, and has been used in nasal breathing research.

In active anterior rhinomanometry, a mask is attached which has a pneumotachometer that has a pressure transducer. The pressure transducer measures the trans-nasal pressure and converts the pressure difference into a voltage signal that is recorded by a computer. The pressure transducer is placed anteriorly at the opening of the non-test nostril, and the patient is asked to breathe normally. The patient breathes through the test nostril while the pressure is measured in the occluded or non-test nostril. The results are plotted graphically as a change in nasal airflow against the nasal pressure differential. The nasal airway resistance (pressure / flow) and the maximum resistance

(resistance at the peak pressure or flow point) can be measured and analysed.

Normal total resistance varies between 0.15 and 0.39 Pa cm^{-3} sec^{-1}, with a mean of 0.23 Pa cm^{-3} sec^{-1}.[90] Nasal resistance measures about 1.2 Pa cm^{-3} sec^{-1} in infants[91,92], and it gradually decreases with age to reach the normal adult value by the age of 16 to 18 years. Thereafter there is a gradual decrease in nasal resistance as the age increases.[93] Physiological variations in resistance can be reduced by decongesting the nose, thus allowing the values to reflect the anatomical characteristics affecting the resistance.[94]

Rhinomanometry has not been routinely used, partly due to the time needed to perform the test, the expense of the equipment, and also due to the poor correlation between nasal resistance and subjective sensation of nasal obstruction.[95] Nasal resistance is dependent upon many physiological variables that can interfere with the measurements - this explains the poor correlation seen using rhinomanometric measurements to diagnose adenoid hypertrophy. If used in the evaluation of adenoids, it is recommended that the nose be decongested prior to the test in order to differentiate between adenoid hypertrophy and other causes of nasal obstruction. It also helps in differentiating between lower grades of adenoid hypertrophy which may be due to mucosal inflammation and will revert with decongestion, as against the higher grades of adenoid obstruction which persist in spite of decongestion. This can help in patient selection for surgery, especially in correlation with the nasal endoscopic findings.[96]

Posterior rhinoscopy

Posterior rhinoscopy involves examining the nasopharynx using a plane mirror. The patient is seated comfortably, the tongue is depressed using a Lack's tongue depressor, and the mirror is introduced along the tongue depressor to just behind the uvula, facing upward. The mirror used is an acutely angled plane mirror with an angulated handle to allow easier visualization. With the patient breathing gently through the nose, the structures in the nasopharynx can be visualized. The pharynx should be anaesthetised with a topical spray prior to the procedure in order to prevent triggering the gag reflex.

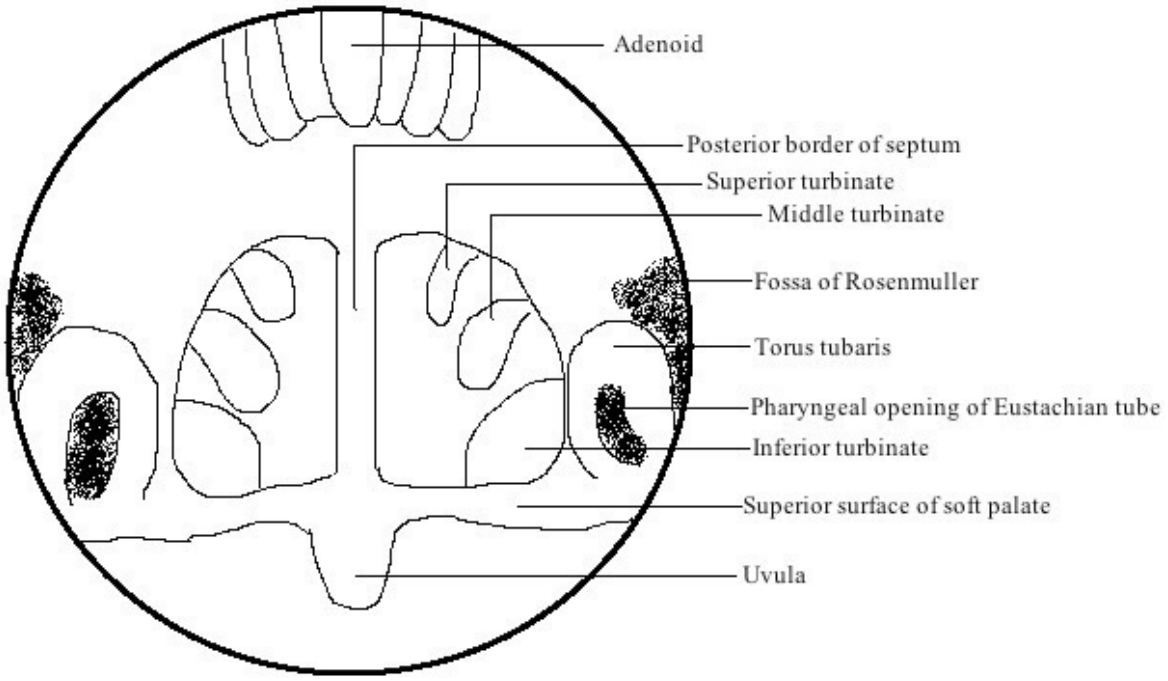


Figure 4: Diagrammatic representation of structures seen on post-nasal mirror examination

Using the posterior rhinoscopy mirror, the structures visualized include the posterior end of the nasal septum, the inferior turbinate, the middle and superior turbinates with

the corresponding meati, the superior surface of the soft palate, the Eustachian tube openings with the torus tubaris, the fossa of Rosenmuller, the roof of the nasopharynx and the adenoid tissue (figure 4).

The advantages of posterior rhinoscopy include the simple equipment and the ease of performing it in the clinic. However, the examination is difficult to interpret, and is operator-dependent. It takes time and experience to adequately visualize the structures of the nasopharynx. The test may not always be adequate if the patient is unable to cooperate. This is especially so in children. Hence, its value is limited in the diagnosis of adenoid hypertrophy in the out-patient department. However, it has been used to grade the adenoids intra-operatively, and this is easily done with the child in the adenoidectomy position and the soft palate retracted. Posterior rhinoscopic assessment of adenoids appears to correlate well with the endoscopic assessment, except in the case of degree of choanal obstruction. Mirror examination consistently underestimates choanal obstruction when compared to endoscopic examination.[97,98] However, it can be used during surgery both to assess the adenoids and to check the completeness of adenoidectomy.

Videofluoroscopy

Videofluoroscopy is a modified Barium swallow which can be used to assess the pharynx. Here, the patient is made to stand at right angle to the table, with one shoulder against the table, and the X-rays are taken after the contrast (Barium sulphate suspension) is injected through a dropper or catheter into the nasal cavity. Various X-ray views can be used to assess different parts of the pharynx. The lateral or mid-

sagittal view is used to assess adenoid hypertrophy. It is a dynamic procedure, and can assess the nasopharyngeal airway during inspiration and during phonation. It is also helpful in assessing patients with cleft palate abnormality who may have symptomatic enlarged adenoids. Although standard practice in the past was that adenoidectomy was not done for patients with cleft palate due to the post-operative velopharyngeal insufficiency that developed, a newer school of thought has proposed partial adenoidectomy in carefully selected patients from this group.

Videofluoroscopy has been shown to be a sensitive and relatively specific test for the evaluation of adenoid hypertrophy.[99] However, it has fallen out of favour in the assessment of adenoids, largely due to the degree of patient cooperation needed for the procedure and due to the radiation exposure involved, especially when other viable substitutes are available. The contrast solution causes a burning sensation in the pharynx which may not be tolerated by the patient. Thus this procedure has been largely replaced by lateral view radiography of the nasopharynx and nasopharyngoscopy in evaluating adenoid hypertrophy.

Endoscopic evaluation of the nasopharynx

Endoscopy of the nasopharynx has become the gold standard test for assessing adenoid hypertrophy of the adenoids. Rigid endoscopy involves passing a rod through the nose or mouth to visualize the nose and pharynx. The rod is based on the Hopkins rod lens system, and has glass lenses separated by air that transmits the image. It also has fibreoptic cables that carry light from the light cable to the tip of the endoscope. The endoscope is connected to a fibreoptic light cable and light source, and a camera

head and monitor to view the image. Rigid endoscope tips may be flat (0 degree), or it may be angulated to provide a different direction of view. Common angulations used include 30 degree, 45 degree and 70 degree. Different diameters of the scopes are available, including 2.7 mm and 4.0 mm. The 4.0 mm endoscope is usually used for adults and older children, while the 2.7 mm endoscope is used for younger children and for narrower nasal passages. Flexible endoscopes are also available - here the tip is mobile and can be angled in either straight, upward or downward to control the movement of the endoscope and the direction of view. The diameter of flexible endoscopes vary between 2.8 mm and 4.2 mm, with the larger endoscopes providing better images but being harder to manipulate in the narrow spaces of a child's nose. Rigid endoscopes provide crisp, clear images and a wider angle of view compared to flexible endoscopes, however flexible endoscopes help in assessing hard-to-view areas. Rigid 0 degree and 30 degree scopes and flexible scopes can be used to assess the nasopharynx.

Endoscopic evaluation of the nasopharynx has the advantage of giving more information regarding the adenoid in relation to its surrounding structures. While radiographs reduce the amount of information of the three dimensional nasopharynx when compressing it into two dimensions, endoscopes give a three dimensional image of the nasopharynx, including structures not well seen on radiographs such as the fossa of Rosenmuller. It permits dynamic assessment of the nasopharyngeal airway, especially in relation to Eustachian tube opening and during swallowing. Endoscopy also allows concomitant assessment of nasal mucosa and pathology which may affect or be consequent to adenoid hypertrophy. Thus, it has become the gold standard for

assessment of adenoid hypertrophy. It is possible to perform endoscopies in children older than 4 years with their cooperation, while it may be difficult in children younger than 3 years of age.

Grading systems of adenoids – advantages and disadvantages

Various methods to assess adenoid size and nasopharyngeal airway have been proposed. The majority of these systems utilize radiographs, either lateral cephalometric or nasopharyngeal X-rays. Using lateral cephalometric X-rays, the methods described are McNamara's, Schulholf's, Holmberg and Linder-Aronson's, and Handelman and Osborne's. Using lateral nasopharyngeal X-rays, the methods described include those by Johannesson, Fujioka, Crepeau, Elwany, Maw, Wang, Mlynarek, Ysunza, Kurien, and Cohen and Konak.[100] These methods are based on a number of parameters which can be measured from lateral cephalometric or nasopharyngeal radiographs. The various parameters which can be assessed are as follows[101]:

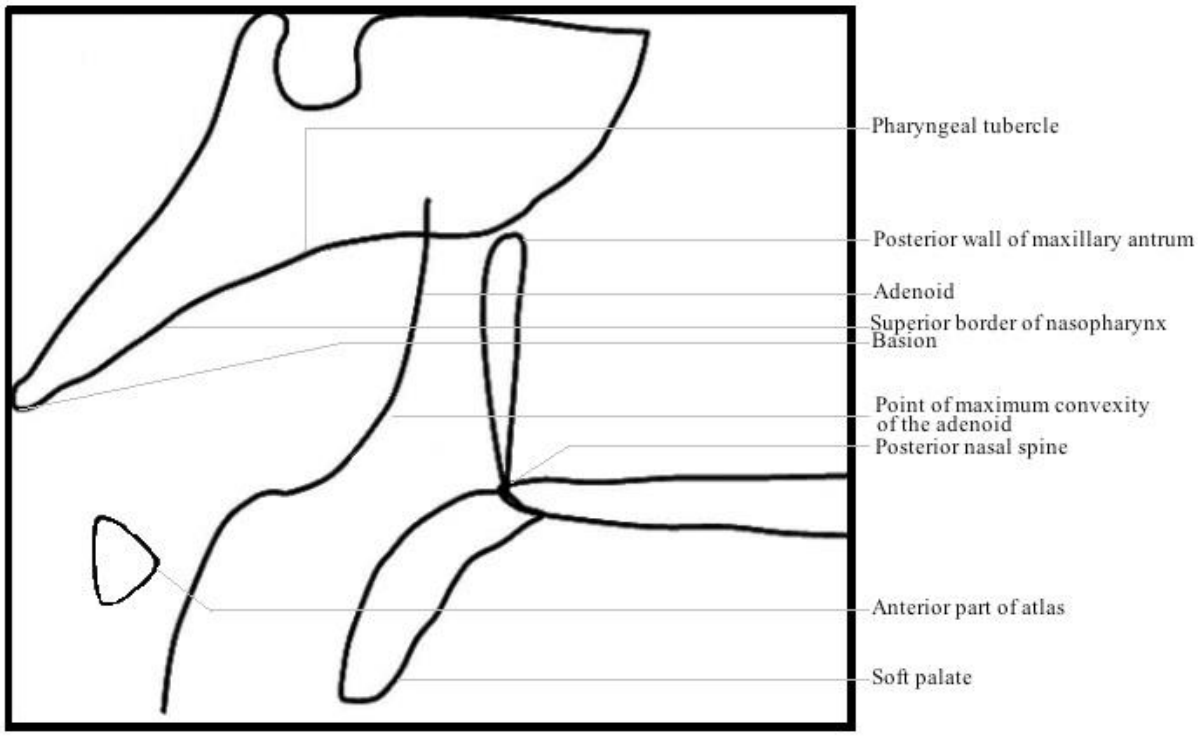


Figure 5: Diagram of landmarks seen on lateral radiographs of the nasopharynx

- *Pharyngeal tubercle*: A point approximately 1 cm anterior to the anterior rim of the foramen magnum, on the inferior surface of the basiocciput, to which the pharyngeal raphe and superior constrictor muscle are attached.
- *Roof of the nasopharynx*: It is formed by the basisphenoid and the basiocciput.
- *Thickness of pharyngeal tonsil or adenoid*: Maximum distance from the basiocciput or pharyngeal tubercle to the point of maximum convexity of the adenoid, along a line perpendicular to the bony roof of the nasopharynx.
- *Nasopharyngeal space*: It is the distance from the posterior end of the hard palate to the posteroinferior margin of the basisphenoid-basiocciput synchondrosis.
- *Antral adenoid*: Shortest distance between the posterior maxillary antral wall at the level of the choana and the anterior border of the adenoid.

- *Passage of air or palatal airway*: Shortest distance between the soft palate and the convexity of the anterior border of the adenoid.
- *Air column*: Distance from the posterosuperior border of the soft palate, 1 cm away from the posterior nasal spine, to the anterior convexity of the adenoid.
- *Soft palate thickness*: It is measured 1 cm away from the posterior nasal spine.
- *Basion*: It is the most inferior point of the anterior border of the foramen magnum.
- *Sphenoid line*: A line drawn through the basion, tangential to the inferior border of the sphenoid bone.
- *Palate line*: It is drawn from the anterior to the posterior nasal spine.
- *Pterygomaxillary line*: It is drawn from the point of intersection of the posterior border of the maxilla with the nasal floor, to intersect with the palate line.
- *Anterior atlas line*: It is drawn through the most anterior point of the atlas, perpendicular to the palate line.
- *Adenoid:nasopharynx ratio*: It is the ratio of the thickness of pharyngeal tonsil to the nasopharyngeal space.

The adenoid mass was quantified by various groups of people by measuring different parameters obtained radiographically, and thus proposing various grading systems. The different grading systems are summarized in table 1.

Table 1: Summary of the radiographic grading systems for adenoids

GRADING SYSTEM NAME	MEASURING PARAMETER	GRADES
Johannesson[102]	Thickness of pharyngeal tonsil.	Distance in millimetres
Fujioka et al[103]	Adenoid:Nasopharynx (A/N) ratio.	Normal: A/N up to 0.8 Enlarged: A/N > 0.8
Crepeau et al[104]	Antral adenoid.	Distance in millimetres
Maw et al[105]	Passage of air or palatal airway.	Distance in millimetres
Cohen and Konak[106]	Air column (AC). Soft palate thickness (SfP). AC/SfP ratio is used.	Small: AC/SfP ≥ 1 Medium: AC/SfP ≥ 0.5 but < 1 Large: AC/SfP< 0.5
Elwany[107]	Adenoid:Nasopharynx ratio (A/N).	Normal: A/N ≤ 0.7 Enlarged: A/N > 0.73
Wang et al[108]	Subjective categorization of adenoid hypertrophy.	Not obvious vs. obvious
Mlynarek et al[109]	Airway occlusion (AWO) = PT/NF where PT is the thickness of the pharyngeal tonsil (as described by Johannesson) and NF is the distance between the pharyngeal tubercle and the soft palate along a line drawn perpendicular to the bony roof of the nasopharynx.	Percentage of airway occlusion
Kurien et al[110]	Palatal airway (PA) or passage of airway.	Grade 1: PA ≥ 6 mm Grade 2: PA ≥ 3 mm but < 6 mm Grade 3: PA < 3 mm

GRADING SYSTEM NAME	MEASURING PARAMETER	GRADES
Ysunza et al[111]	Subjective grading of adenoid hypertrophy.	Grades 1 to 4
Handelman and Osborne[112]	Nasopharyngeal airway area - calculated using the following markers: 1) Sphenoid line, 2) Pterygomaxillary line, 3) Palate line, 4) Anterior atlas line.	Nasopharyngeal airway area (percentage of air space after subtracting the adenoid area from the area calculated between the drawn lines)
Schulhof[113]	Shortest distance between the adenoid border and a point 5 mm above the posterior nasal spine.	Distance in millimetres
Holmberg and Linder-Aronson[114]	Subjective grading of adenoid size.	Small; Moderate; Large; Very Large
McNamara Jr.[115]	Shortest distance from the superior border of soft palate to the anterior border of adenoid.	Non-obstructive: Distance > 5 mm Apparently obstructive: Distance ≤ 5 mm

All of these grading systems are simple to measure. Radiographs are easy to obtain. The various parameters assessed are consistent between examiners. However, they require some cooperation from the child in terms of positioning and in breathing through the nose (which may be difficult in children who have obstructive adenoids or who are agitated and crying). Radiographs provide a certain amount of information regarding nasopharyngeal airway in the anteroposterior dimension (assessed on lateral view radiographs). However side-to-side airway compromise or coronal cut

information is lacking. Also, while gross enlargement of the adenoid volume can be assessed, its relation to the Eustachian tube and tubal occlusion or dysfunction cannot be assessed. Intrusion of the adenoid tissue into the nasal cavity with partial obstruction of the choanae may not be accurately assessed.

The grading systems which utilize length measurements alone without any classification or typing (Johannesson, Crepeau, Maw, Schulhof) are not useful as these measurements do not have normative data with which to compare them. The subjective grading system proposed by Wang et al is too simplistic for use in guiding management - it ignores the variation in size possible in obviously enlarged adenoids, and does not differentiate between adenoid enlargement which can possibly be managed conservatively, and adenoid enlargement which needs definitive surgical treatment. The grading by Ysunza and Holmberg and Linder-Aronson is similar to the Brodsky grading system used for grading tonsillar enlargement clinically, however an eyeball assessment of a single dimension of adenoid hypertrophy misses out on a lot of information which may be needed to guide further treatment. It is useful in the higher grades of adenoid hypertrophy and in children with obstructive symptoms, where the test may be performed merely to confirm the diagnosis prior to surgical management. However, discrepancies in size between such subjective adenoid assessments and objective adenoid tissue volume measurements have been noted, especially in the smaller grades. Mlynarek's grading based on percentage of airway occlusion is subject to the patient cooperating adequately for the radiological examination. In case of a crying child or an improperly positioned child, the airway occlusion may be over-estimated and may lead to unnecessary surgeries. McNamara's

method is similar to the antral adenoid measurement used by Crepeau, and both of these may be used to diagnose severe adenoid obstruction, but they are limited in their description. Handelman and Osborne's system is impractical in the clinical setting as it requires software to calculate the area of the nasopharyngeal airway, and required multiple measurements to calculate area - this is too expensive and time-consuming for routine evaluation. Kurien et al used the palatal airway measurements as described by Maw, but gave clear gradings and cut offs - these are useful in clinical decision making. However, while their inter-rater and intra-rater reliability was very good, they did not correlate well with video nasopharyngoscopy and sensitivity was low.[116]

The adenoid:nasopharynx ratio, which was used by both Fujioka and Elwany, has been studied extensively. The length of the adenoid (thickness of pharyngeal tonsil) was described as the maximum distance from the basiocciput or pharyngeal tubercle to the point of maximum convexity of the adenoid along a line drawn perpendicular to the bony roof of the nasopharynx. The length of the nasopharynx has been variably described. Fujioka originally described it as the distance from point A - the point of intersection of the basiocciput with the posterior border of the pterygoid plate, to point B - the posterior border of the hard palate. This was modified by Elwany as the distance between the posterior end of the hard palate and the posteroinferior margin of the basisphenoid-basiocciput synchondrosis. Where the synchondrosis was not clearly visualized, it was described as the distance from a point on the anterior basiocciput (closest to the intersection of the line measuring thickness of pharyngeal tonsil with the anterior margin of the basiocciput) to the posterior border of the hard palate. The ratio of the two lengths (thickness of pharyngeal tonsil to the nasopharyngeal length)

was described as the adenoid:nasopharynx ratio. Fujioka had noted a change in the mean adenoid:nasopharynx ratio as the child grew, from 0.55 at the age of 1 year, to a maximum of 0.59 at almost 5 years, and decreasing again to 0.52 by the age of 12 years. Elwany's study determined that a cut-off of 0.73 for the adenoid:nasopharynx ratio for any child between the ages of 2 years and 12 years would have very low false positive (2%) and false negative (6%) rates. The advantage of the adenoid:nasopharynx ratio is that it takes into account both the adenoid and nasopharyngeal dimensions. This is especially important in younger children in whom the adenoid size may outpace the growth of the nasopharynx and thus lead to symptoms. It is also not dependent on soft palate position for measurements - this eliminates errors, which can arise since the soft palate is a mobile structure. The disadvantages of the adenoid:nasopharynx ratio include the need for proper patient positioning and exposure of the film so as to obtain clear landmarks, and its inadequacy while evaluating obstructive sleep apnoea.[117]

A grading system based on mirror examination of the post-nasal space while the child is under anaesthesia was proposed by Josephson et al – this is described in table 2.[118]

Table 2: Josephson et al grading of adenoid hypertrophy using post-nasal mirror examination

Adenoid size	Choanae	Eustachian tube
0 - No adenoid tissue present	A - No obstruction	- Not abutting Eustachian tube or in fossa of Rosenmuller
1 - 1-25 %	B - Partial obstruction	+ Abutting Eustachian tube and/or in fossa of Rosenmuller
2 - 26-50 %	C - Complete obstruction and/or adenoid tissue extending into the nasal cavity	
3 - 51-75 %		
4 - 76-100 %		

This grading system is similar to the proposed A.C.E. grading system under study, with a few modifications. It is sufficiently descriptive of the adenoids and is useful for intra-operative documentation. Each variable is independent of the other variables and thus, a complete picture of the adenoids in relation to its surroundings is obtained. However, posterior rhinoscopy is difficult to perform in children in the out-patient setting as it requires tremendous patient cooperation - a fact acknowledged by the authors Josephson et al when they suggested that the grading could be adapted to fibreoptic examination to allow ease in performing it in awake children in the clinic

and also under general anaesthesia. This grading also tends to underestimate the degree of choanal obstruction, as it views the choanae from below (oropharynx) causing a certain amount of parallax error.

Video nasopharynoscopy or endoscopic examination of the nasopharynx has replaced all the other tests as the gold standard in the assessment of adenoid enlargement. Several grading systems have been proposed based on nasopharyngeal endoscopy, which are described below:

Table 3: Summary of grading systems for adenoid enlargement using endoscopic examination

GRADING SYSTEM NAME	PARAMETERS	GRADES
Wormald and Prescott[119]	Degree of choanal involvement	Grade 1: 1/3rd of choana (till upper edge of torus) is compromised Grade 2: Up to 2/3rd of choana is compromised (may compress Eustachian tube opening) Grade 3: More than 2/3rd of choana is involved
Parikh[120]	Relationship of the adenoids to the torus tubaris, vomer, and soft palate	Grade 1: Adenoids not in contact with torus tubaris, vomer, or soft palate Grade 2: Adenoids in contact with torus tubaris Grade 3: Adenoids in contact with torus tubaris and vomer Grade 4: Adenoids in contact

GRADING SYSTEM NAME	PARAMETERS	GRADES
		with torus tubaris, vomer and soft palate
Clemens et al[121]	Degree of choanal obstruction	Grade 1: Adenoid tissue filling 1/3rd of vertical portion of choanae Grade 2: Adenoid tissue filling from 1/3rd to 2/3rd of choanae Grade 3: Adenoid obstructing 2/3rd of choanae to almost complete obstruction Grade 4: Complete choanal obstruction
Wang[122]	Distance from the vomer to the adenoid tissue	Small: Distance > 1 cm Moderate: Distance between 0.5 to 1 cm Large: Distance < 0.5 cm
Cassano et al[123]	Degree of choanal obstruction – measured by the area covered by adenoids between the upper border of choana to the nasal floor	Grade 1: < 25% of choana involved Grade 2: 25-50% of choana involved Grade 3: 50-75% of choana involved with or without partial closure of Eustachian tube opening Grade 4: 75-100% of choana involved with obstruction of tubal opening

Each of these grading systems looks at one dimension of the adenoids. Wormald and Prescott's grading is limited to the degree of choanal obstruction. This does not take into account smaller adenoids which may still cause dynamic obstruction of the Eustachian tube. It also does not allot a description for adenoids which do not intrude into the choanae. The same drawbacks apply to the grading by Clemens et al and by Cassano et al. The grading system by Cassano et al is similar to the Brodsky grading used for adenoids. Wang's grading only takes into account the nasopharyngeal airway but does not describe Eustachian tube obstruction. The grading by Parikh is more descriptive in that it takes into account the structures surrounding the adenoids, but it is arbitrary (contact of adenoids with torus tubaris, vomer and soft palate - in that order) and does not make allowance for other combinations associated with adenoid enlargement.

Thus in spite of the varied grading systems which have been put forward, there is no consensus grading system which has been widely accepted and which provides a complete description of the adenoids and related nasopharynx in order to facilitate communication. In view of the symptoms and significant morbidity associated with adenoid hypertrophy due to its high prevalence in children, there is a need for a new comprehensive grading system which can be done with ease in children and provides consistent results when repeated.

Endoscopic A.C.E. grading system

This grading system is labelled A.C.E. after the variables it measures. It is similar to the grading proposed by Josephson (based on mirror examination of the post-nasal space). The A.C.E. grading system is described below[124]:

Table 4: Endoscopic A.C.E. grading system of adenoids

A - Adenoid size	C - Choanal obstruction	E - Eustachian tube
0 - No adenoids	0 - No obstruction	0 - Not abutting Eustachian tube
1 - 1% to 25%	1 - <50% obstruction	1 - Abutting Eustachian tube
2 - 26% to 50%	2 - >50% obstruction	
3 - 51% to 75%		
4 - 76% to 100%		

The adenoid size is described in relation to the degree of nasopharyngeal volume it occupies. The degree of choanal obstruction is based on the relation of the adenoid to the posterior end of the septum and the vomer. Tubal obstruction is graded as present or absent. The final grade would be represented as A-C-E-. Thus each parameter is independent of the others and all possible combinations of presentation of the adenoid can be represented. This provides a comprehensive way of describing the adenoid mass endoscopically in relation to the nasopharyngeal space, taking into consideration the relevant structures close by, thus making it a good descriptive grading system.

In the study, the grading system was performed on children under general anaesthesia after decongesting the nose with xylometazoline and 4% lignocaine nasal drops. Rigid

nasal endoscopy was performed with a 2.7 mm rigid endoscope following decongestion, and the scope was positioned with the posterior end of the inferior turbinate just visible. The entire choana was visible from this point, and the pharyngeal opening of the Eustachian tube could also be seen (figure 6).

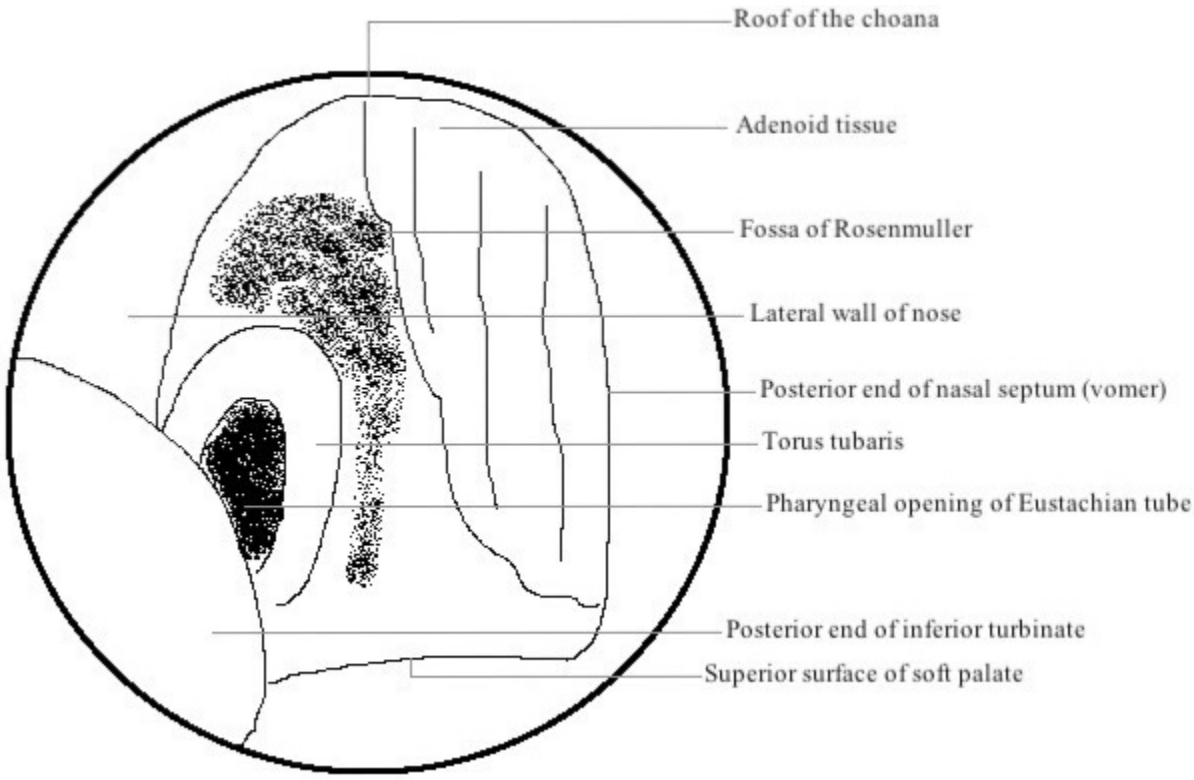


Figure 6: Diagram of structures seen on nasopharyngoscopy through the right nostril

This provided a view of the adenoids and its association with the peripheral structures. The grading was subjective, however it correlated well with symptomatology. The larger ‘A’ grades were shown to be associated with sleep disordered breathing (an expected finding) and the smaller ‘A’ grades with chronic adenotonsillitis. This is explained by the presence of fibrosis due to persistent inflammation in chronic adenotonsillitis, and thus the smaller size of the adenoids. The size of the adenoids

belies the higher level of inflammatory processes present within it. The C component also correlated well with sleep disordered breathing. Both the A and the C components did not show an association with conditions secondary to Eustachian tubal block. These conditions (otitis media with effusion, recurrent acute otitis media, and chronic otitis media) showed significant association with the perceived Eustachian tube obstruction by adenoids as assessed during endoscopy.

As per the original study, this grading was initially used to describe the intra-operative appearance of the adenoids, utilizing more variables instead of an absolute score to ensure a more complete description. Its uses were extrapolated to the clinical setting to enhance pre-operative decision making, and for follow up of adenoids. One of the limitations of a study with multiple variables is that as the number of variables in the grading system increases, the chance for variability in the grade between examiners and also by the examiner at different times increases. This chance is more so because it is based on eyeball estimation instead of concrete measurements. Eustachian tube occlusion and choanal obstruction are dynamic measures which can vary as the child swallows, cries, speaks, or inhales through the nose. Another limitation is related to the assessment of Eustachian tubal block - children with smaller adenoids with Eustachian tube dysfunction during assessment may be advised surgery - however, this does not take into account the role of allergy and other mucosal pathology which may cause tubal block independent of adenoids. In such cases, surgery will not correct tubal dysfunction and the patient may present with recurrence or persistence of his ear complaints. Thus, this grading system needs to be assessed both for its utility in the clinical out-patient setting and for assessment of its reliability between examiners. The

replicability of the associations between adenoid hypertrophy and clinical symptoms also needs to be assessed. Thus the reliability and reproducibility of this adenoid grading system need to be tested to decide whether it is a useful tool in the assessment and management of conditions caused due to adenoid hypertrophy.

Assessing test reliability

Test reliability is important in order to qualify the test as clinically useful. In other words, the test or grading should give the same value each time it is performed, and the result should be the same regardless of whether the same person does it multiple times or whether different people do it. This aids in communicating results - what an examiner describes will be accurately understood by the listener. Thus for any test or grading to be widely accepted, its inter-rater variability and intra-rater variability need to be assessed.

When using any scoring system or test, the observed score (or the grade or result obtained from the test) is not the true value or score of the test - it is a reflection of the true score and the measurement error. This can be represented with the following equation:

Observed score = True score + Measurement error

Similarly, the variance of the observed score is the sum of the variance of the true score and the variance of the measurement error. In cases where the measurement error is very small, the observed score is the same as or very near the same as the true

score. In cases where the measurement error is large, the observed score will vary more from the true score. The measurement error can be due to systematic errors or random errors. Systematic errors are predictable, while random errors occur due to chance and are unpredictable. Thus reproducibility aims to quantify the measurement errors. Measurement errors can also arise due to imprecision or inaccuracy while measuring, due to a faulty scaling of the test instrument, or due to instability of the test instrument or scoring in measuring the same subjects over time, or when involving different raters.

Tests or scoring systems can be classified as discriminative or evaluative. Discriminative tests aim to distinguish between patients, and thus the measurement error should be small compared to the difference between the patients which is being measured (subject variability). Evaluative tests on the other hand are meant to assess the same patient over time (accuracy of measurement for each patient), and thus subject variability is not important. In evaluative tests, only the measurement error is important, and this should be smaller than the changes (improvement or worsening) of the patient which need to be measured. This leads to the two aspects of test reproducibility, which are agreement and reliability. Agreement of a test or scoring system implies the agreement between different measurement by different raters or by the same rater at different times for the same subject. Reliability, on the other hand, assesses how well the test or scoring system differentiates between different subjects. Thus, reliability is a descriptive characteristic of discriminative tests, while agreement is a characteristic for evaluative tests.

Both reliability and agreement are measured in test-retest situations, which might

mean the same test or scoring system being performed at different times or under different conditions, with different raters, or with the same rater at different times. Both can be represented as below:

Agreement = Standard difference between repeated measurements for a single subject

$$\textit{Reliability} = \frac{\textit{Variability between subjects}}{\textit{Variability between subjects + Measurement error}}$$

Inter-rater variability is a method to quantify the agreement between raters. It shows how much of the variance in the observed score is due to the variance in the true score after removing the variance in the measurement error. Kappa statistics are used to describe inter-rater variability for nominal variables. Intra-class correlation is used to describe inter-rater variability for ordinal, interval and ratio variables. When designing a study to assess inter-rater reliability, it may be fully crossed which means the subjects are rated by the same set of raters, or not cross which means that different subjects are rated by different sets of raters. The fully crossed design is better because it allows for assessment and control of systematic bias between raters. Certain properties of the test instrument can also affect the inter-rater reliability. In case of decreased variance of the true scores due to a change in the subject population, the inter-rater reliability may show falsely low values. This may be due to a different, non-normally distributed prevalence of the characteristic under study by the test instrument. Raters may also need to be trained with practice subjects prior to assessing the actual study subjects in order to ensure a certain level of inter-rater reliability is achieved. One problem with low inter-rater reliability is the increased risk of type 2

errors (decreased ability of the study to detect a relationship that exists) due to an increase in the measurement error. Thus, it also affects the power of the study.

Kappa statistics which are used to assess inter-rater reliability for categorical variables between two raters are of many types. Kappa measures the observed agreement between raters and corrects for any agreement arising out of chance. It is represented by the following formula:

$$K = \frac{P(A) - P(E)}{1 - P(E)}$$

where K - kappa

P(A) - observed percentage of agreement

P(E) - probability of expected agreement being due to chance

Kappa values can range between -1 to 1, where a value of 1 indicates perfect agreement.

Cohen's kappa was the statistic originally described. Two problems with Cohen's kappa are the prevalence problem and bias. In prevalence problems, the distribution of observed ratings falls under one category of the test instrument or rating scale at a higher rate than the others, causing kappa to be very low. This can be due to the nature of the rating scale, or due to a tendency of the raters to identify one group in the rating scale more than the others, or due to an unequal prevalence of the test events in the population under study. Bias occurs when the distribution of specific ratings are extremely different between raters, causing a very high kappa value. In order to correct the prevalence problem, Byrt et al described a modification of kappa.

Similarly, Siegel and Castellan's kappa offered bias correction. However, no kappa description has been able to correct for both bias and prevalence problems. In some cases, it is more important to know by how much the raters differed in their scoring of a subject, than to know absolutely if they disagreed or not. For example, in a rating scale from 1 to 5, the degree of disagreement is more if one rater gives a score of 1 and the other gives a score of 4 than if one rater gives a score of 3 and the other gives a score of 4. In such situations, weighted kappa is used. This assigns different weights based on the level of disagreement between the assigned scores.

In conclusion, the adenoids with their enlargement and the associated conditions are a common problem of childhood, which can have significant effects on the child's development and quality of life. Due to their position in the nasopharynx, the adenoids are not amenable to easy visualization. Nasal endoscopy has become the gold standard test for assessment of adenoid hypertrophy. While many grading systems using nasal endoscopy have been proposed, none have been universally accepted. The A.C.E. endoscopic grading system offers a good descriptive scale to assess the adenoids and its relation to the surrounding structures. It remains to be checked whether the scale is reliable for routine clinical use.

MATERIALS AND METHODS

This study was done conducted at the department of Otorhinolaryngology of the Christian Medical College, Vellore. Institutional review board approval was obtained in the IRB Min no: 10262 [OBSERVE] dated 05.09.2016. The study was done by recruiting patients between the ages of 3 years and 16 years who had been planned to undergo adenoidectomy between September 2016 and August 2017.

Study design

Prospective observational study.

Study period

September 2016 to August 2017.

Setting

The study was conducted at the Department of Otorhinolaryngology in the Christian Medical College, Vellore. CMC Vellore is a tertiary referral centre in Tamil Nadu that caters to patients from Tamil Nadu and other parts of India as well as from neighbouring countries. The hospital has an average of 7500 out-patients and 2300 in-patients with a daily bed occupancy rate of approximately 79% as of the 2016 hospital records.

Participants

All children undergoing adenoidectomy or planned for adenoidectomy in the Department of Otorhinolaryngology, Unit 2 in the Christian Medical College, Vellore were selected for the study after obtaining informed consent. They were evaluated

based on the clinical protocol.

Inclusion criteria:

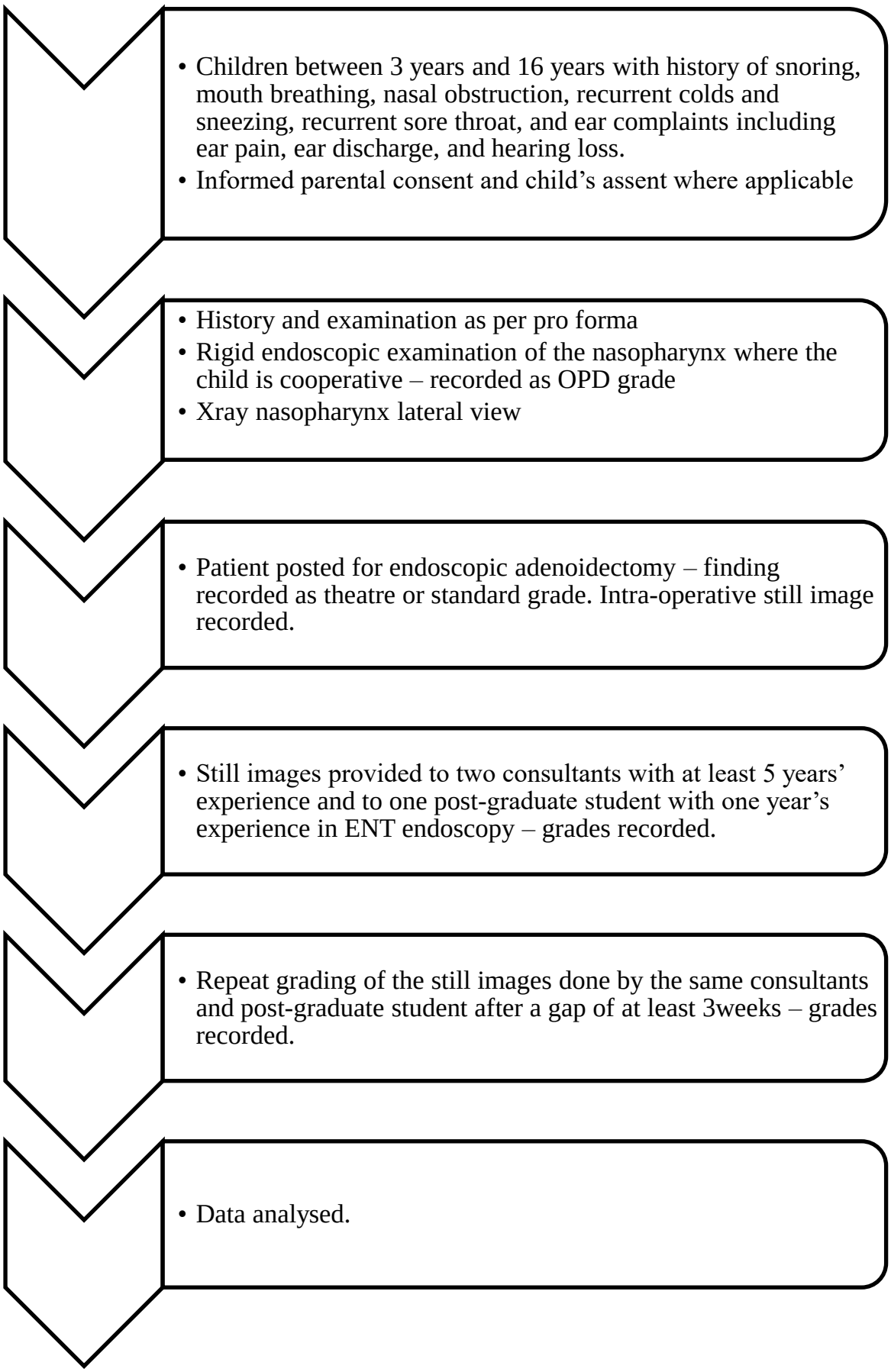
1. Children between 3 years and 16 years of age undergoing adenoidectomy in the Department of Otorhinolaryngology, Unit 2 of the Christian Medical College, Vellore.

Exclusion criteria:

1) Patients with craniofacial anomalies where nasopharyngeal anatomy may be altered (including syndromic children like those with Down's syndrome, cleft palate, etc.).
2) Prior history of adenoidectomy.
3) Patient or the caregiver refusing the procedure.

Methodology

Children who satisfied the inclusion and exclusion criteria were invited to participate in the study and were provided with the study information sheet. After obtaining parental consent and the child's assent (if the child was above 7 years of age), the patients were included in the study. A detailed history and thorough ENT examination were obtained according to the pro forma enclosed in the annexure.


• Children between 3 years and 16 years with history of snoring, mouth breathing, nasal obstruction, recurrent colds and sneezing, recurrent sore throat, and ear complaints including ear pain, ear discharge, and hearing loss.
• Informed parental consent and child's assent where applicable
• History and examination as per pro forma
• Rigid endoscopic examination of the nasopharynx where the child is cooperative – recorded as OPD grade
• Xray nasopharynx lateral view
• Patient posted for endoscopic adenoidectomy – finding recorded as theatre or standard grade. Intra-operative still image recorded.
• Still images provided to two consultants with at least 5 years' experience and to one post-graduate student with one year's experience in ENT endoscopy – grades recorded.
• Repeat grading of the still images done by the same consultants and post-graduate student after a gap of at least 3weeks – grades recorded.
• Data analysed.

Those children who cooperated underwent endoscopic evaluation of the nasopharynx at the pre-operative evaluation to assess the amount of adenoid hypertrophy (recorded as the OPD grade). This was done after nasal decongestion using 0 degree rigid endoscopes of 2.7 mm diameter in smaller children and 4.0 mm diameter in bigger children (Karl Storz endoscopes). These children then underwent adenoidectomy under general anaesthesia. After the child was positioned and draped, the nasal cavities were decongested with a topical solution of 0.05% xylometazoline, following which nasal endoscopy was done with 2.7 mm 0 degree rigid endoscopes (Karl Storz). With the endoscope positioned at the posterior end of the inferior turbinate, still images were captured with a camera (Karl Storz– TELECAM SL II single chip camera) of the adenoid and nasopharynx. At the same time, the adenoids were graded by a consultant with more than five years' experience and this was recorded as the theatre grade which was taken as the standard grade. The still pictures were assembled. Three raters were chosen for the study – this included two Otorhinolaryngology consultants with more than five years' experience, and a post-graduate trainee with experience in routine nasal endoscopy for at least one year. After blinding the two consultants and the post-graduate registrar, the pictures were administered to them for rating. This was recorded as the first test grading. The same pictures were shown to the same raters after a period of at least three weeks, and the repeat grading was recorded as the second test grading. Meanwhile, demographic and clinical data was recorded for the patients in the study.

For analysis, the grading was compared both within and between raters. The first test grading provided by each rater was compared with the second test grading provided

by the same rater to assess consistency. The first test grading of all raters was compared to assess the inter-rater reliability. The first test grading of all raters was also compared to the theatre grade to assess reliability. In addition, the OPD grade was compared with the theatre grade to determine whether the proposed grading system could be used in the OPD for routine assessment.

Sample size calculation

The sample size was calculated using the following formula:

$$n = \frac{\left(z_{\alpha} + z_{1-\beta}\right)^2}{\left\{\pi(1-\pi)(\rho_1 - \rho_0)\right\}^2}\left[\frac{1}{\pi^2+\pi(1-\pi)\rho_0} + \frac{2}{\pi(1-\pi)(1-\rho_0)} + \frac{1}{(1-\pi)^2+\pi(1-\pi)\rho_0}\right]$$

Where,

ρ_0 : Null hypothesis Agreement

ρ_1 : Alternative hypothesis agreement

π : Prevalence

α : Significance level

1- β : Power

Here, with a prevalence of adenoids of 73.2%, power of 80%, alpha error of 5%, population agreement of 71% (determined from previous studies), and expected sample agreement of 85%, the sample size was determined to be 205.

Data analysis

The data was entered using EpiData software, and analysed. Cronbach's alpha and the intra-class correlation coefficient (ICC) were used to determine reliability, while Cohen's weighted kappa was used to assess agreement.

RESULTS

A total of 124 patients were recruited during the study period.

I. Demographic profile

I.1 Age

Majority of the children were between 4 years and 9 years of age. The median age was 6 years, with a mean of 7.3 years and a mode of 4 years.

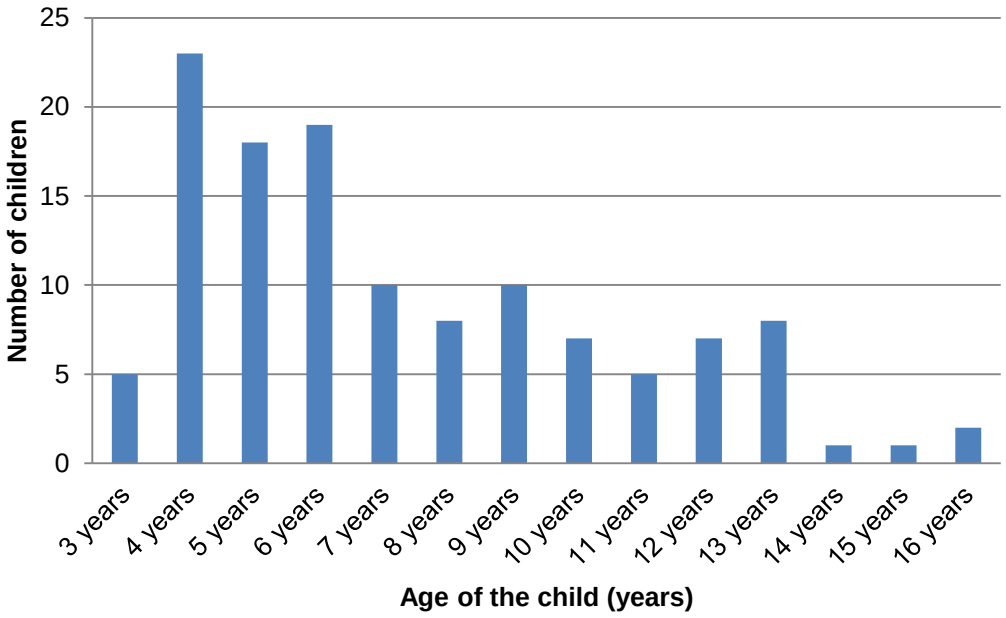


Figure 7: Age distribution of children in the study population

I.2 Gender

70.2% of the study population were male (n=87) and 29.8% were female (n=37).

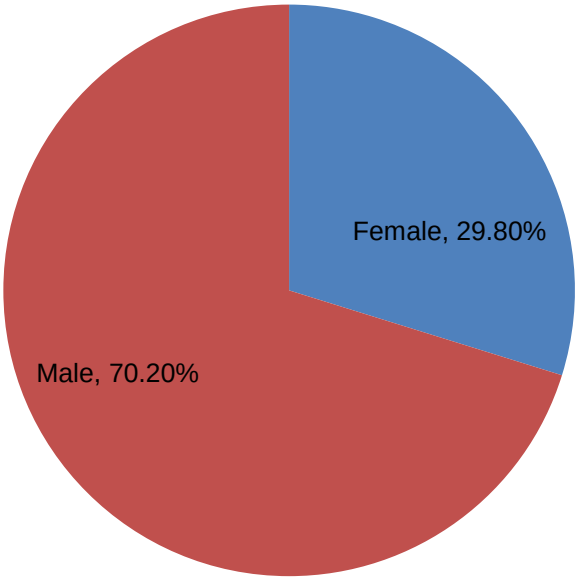


Figure 8: Sex distribution in the study population

II. Clinical profile

II.1 Distribution of symptoms

The commonest symptoms at presentation were mouth breathing (81.5%) and recurrent colds (78.2%), followed by snoring (76.6%) and nasal obstruction (73.4%).

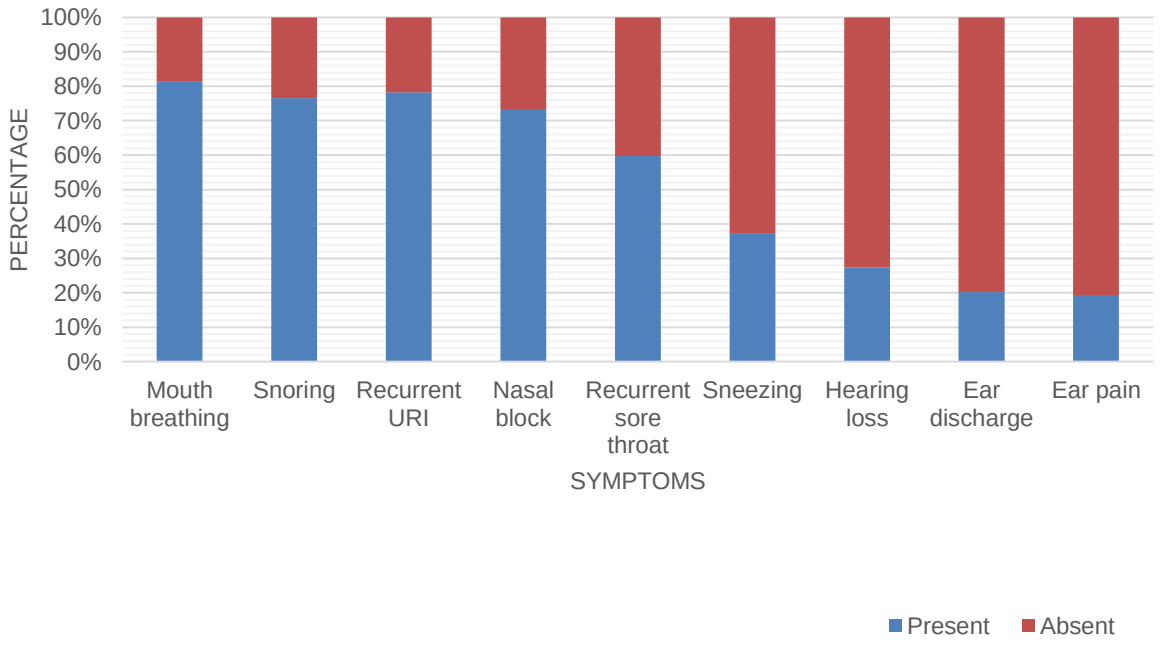


Figure 9: Distribution of symptoms (in percentage) among the study population

II.2 Examination findings

Majority of the children had tonsillar enlargement (89.5%). Approximately one-third of the children (32.3%) were noted to have mucoid nasal discharge.

In ear examination, a normal tympanic membrane was seen in 50 children (40.3%). Among the remaining 74 children, the ear findings were distributed as follows:

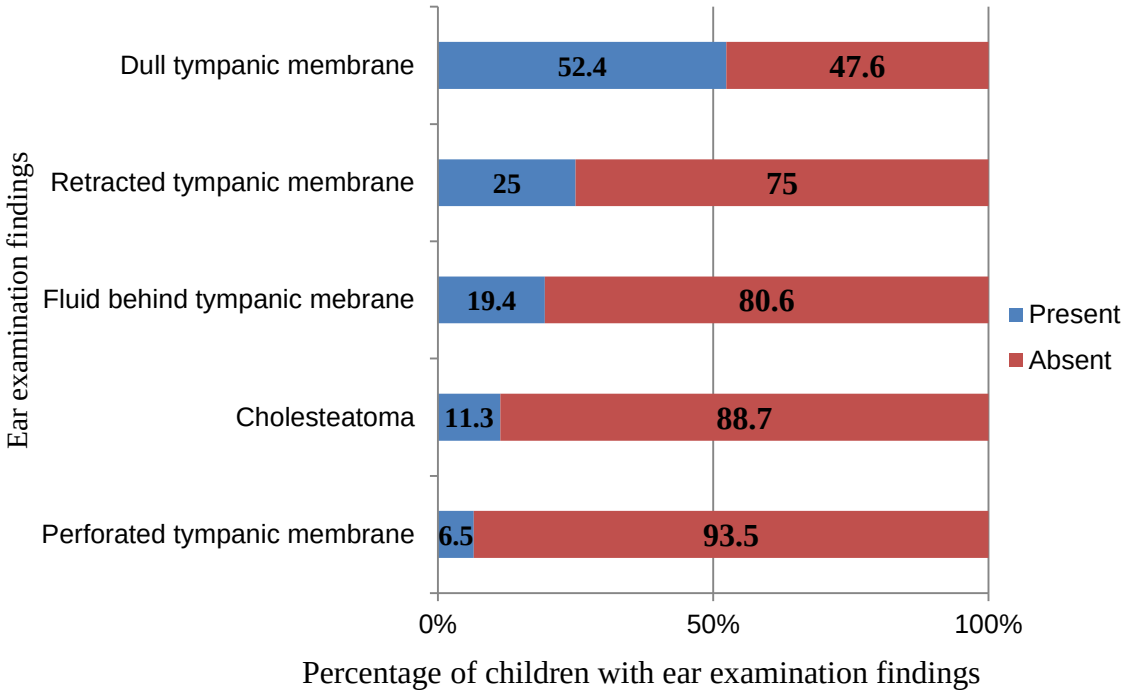


Figure 10: Distribution of ear examination findings in the study population

II.3 Investigation findings

Based on the history and examination, patients underwent pure tone audiometry, tympanometry, X-ray nasopharynx lateral view and/or rigid nasal endoscopy.

Based on pure tone audiometry, 47% of the patients who had undergone audiometry had conductive hearing loss. 7 children out of 124 did not undergo audiometric evaluation.

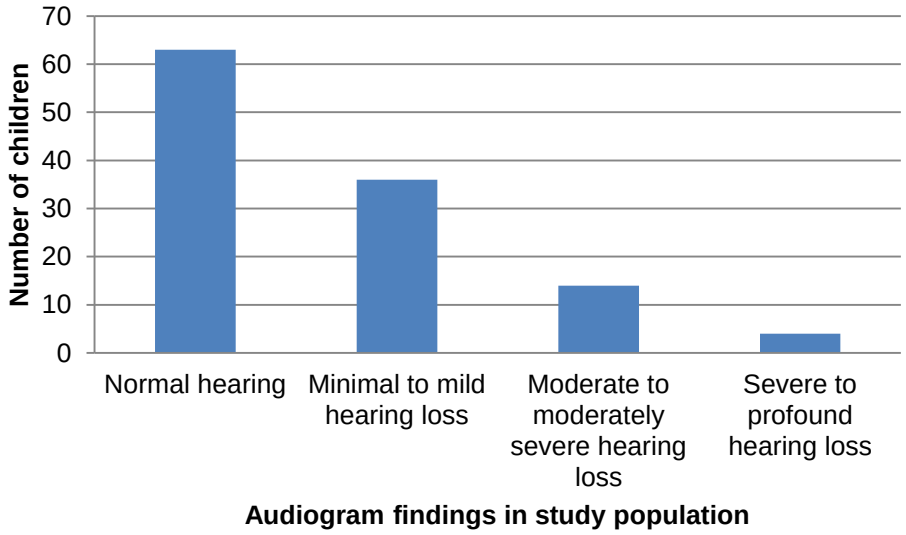


Figure 11: Pure tone audiometric findings in the study population

Tympanometry was performed in 109 children. Data on the Eustachian tube obstruction based on theatre grade was available for 106 of these children. The results were as follows.

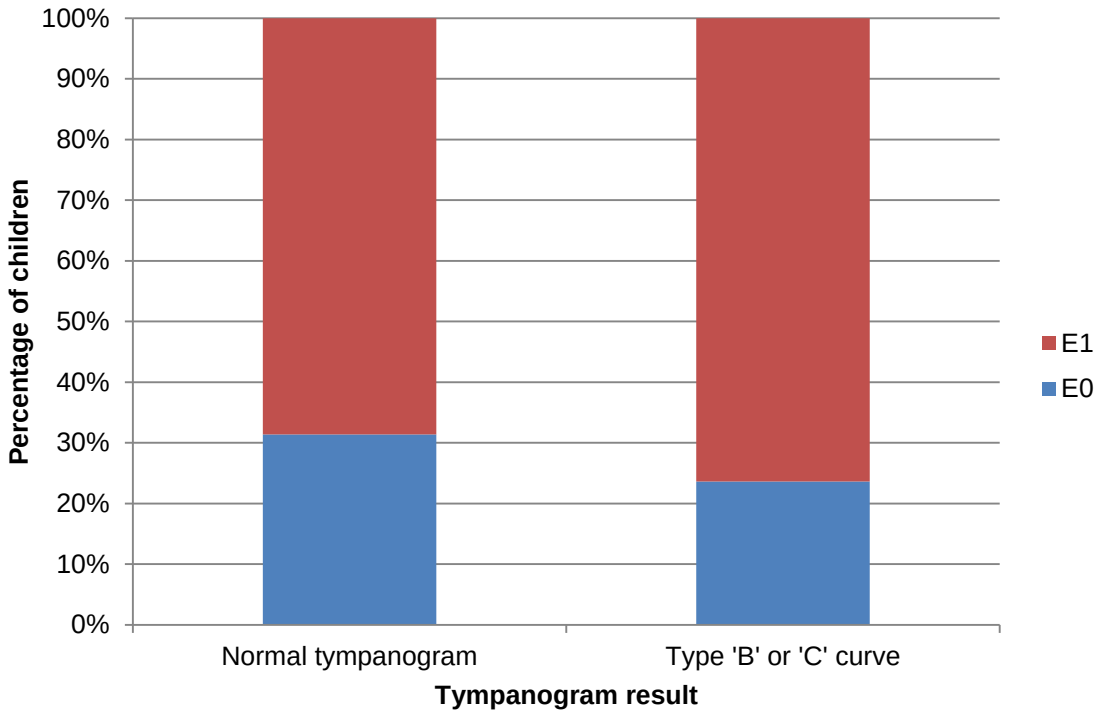


Figure 12: Comparison of tympanometry results in the study population with the presence of Eustachian tube obstruction on theatre grade

Of a total of 51 children with a normal tympanogram, 68.6% had an obstructed Eustachian tube (‘E1’ grade), while of 55 children with a type ‘B’ or type ‘C’ curve on tympanometry, 76.4% had an obstructed Eustachian tube.

Lateral view X-ray nasopharynx was obtained in 83 children. The distribution of adenoid grades on X-ray nasopharynx was compared to the corresponding ‘A’ grade from the theatre grading.

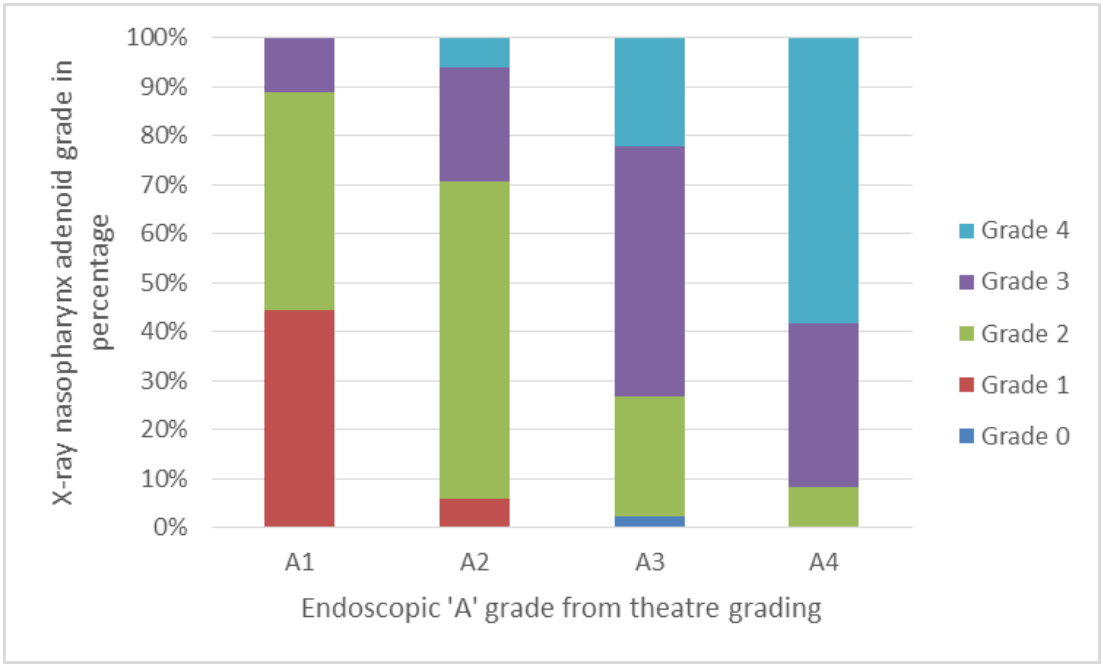


Figure 13: Comparison of adenoid ‘A’ grade from the theatre grading with lateral view X-ray nasopharynx adenoid grade

II.4 Clinical diagnosis

Of the 124 children, 74 had been diagnosed with chronic adenotonsillitis.

The remainder comprised of chronic adenoiditis or chronic adenoid hypertrophy, with or without tonsillar hypertrophy.

Table 5: Distribution of diagnoses in the study population

Diagnosis	Without OME	With OME	Total
Chronic adenoid hypertrophy	27	12	39
Chronic adenotonsillitis	66	8	74
Chronic adenotonsillar hypertrophy	8	3	11

Of 124 children in the study population, 96 had features of sleep-disordered breathing (SDB). Data on the degree of choanal obstruction from the theatre grade was available for 93 of these patients. The presence of sleep disordered breathing was correlated with the degree of choanal obstruction.

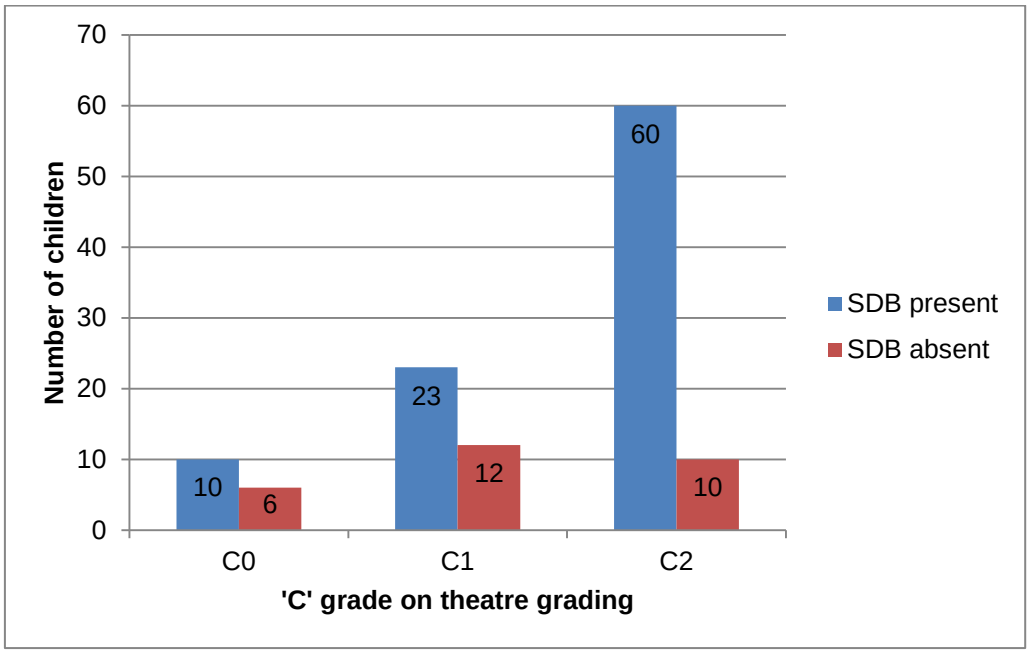


Figure 14: Correlation between presence of sleep disordered breathing and degree of choanal obstruction on theatre grading

The ‘A’ of theatre grade (adenoid size) was correlated with the presence of sleep disordered breathing and chronic adenotonsillitis.

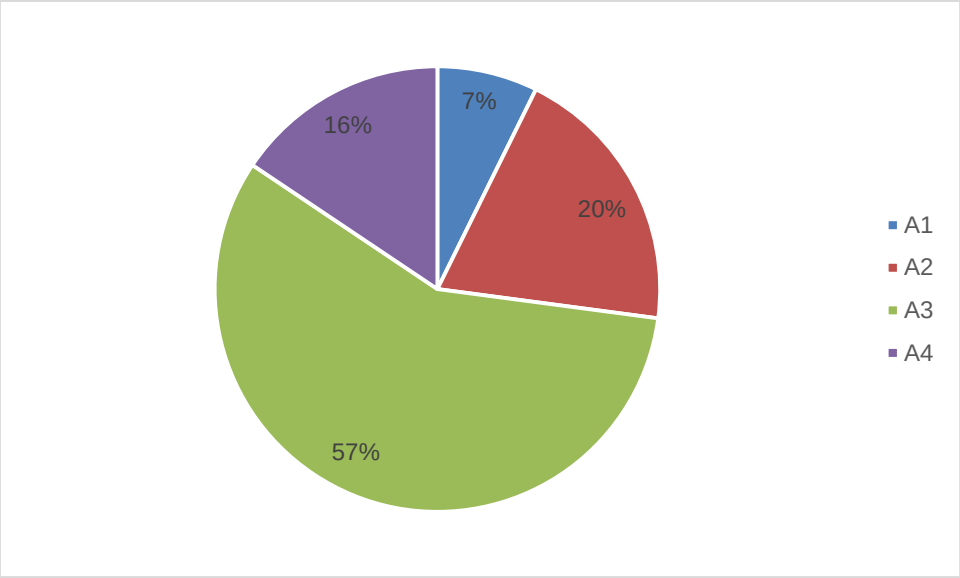


Figure 15: Distribution of adenoid ‘A’ grades in children with sleep disordered breathing

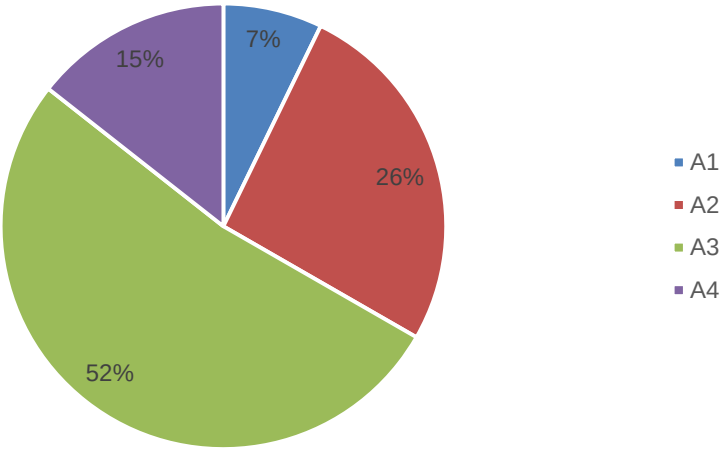


Figure 16: Distribution of adenoid ‘A’ grades in children with chronic adenotonsillitis

The patients with ear complaints were diagnosed variously with otitis media with effusion, chronic otitis media mucosal disease, or chronic otitis media squamosal disease. The distribution of the various ear conditions are shown below.

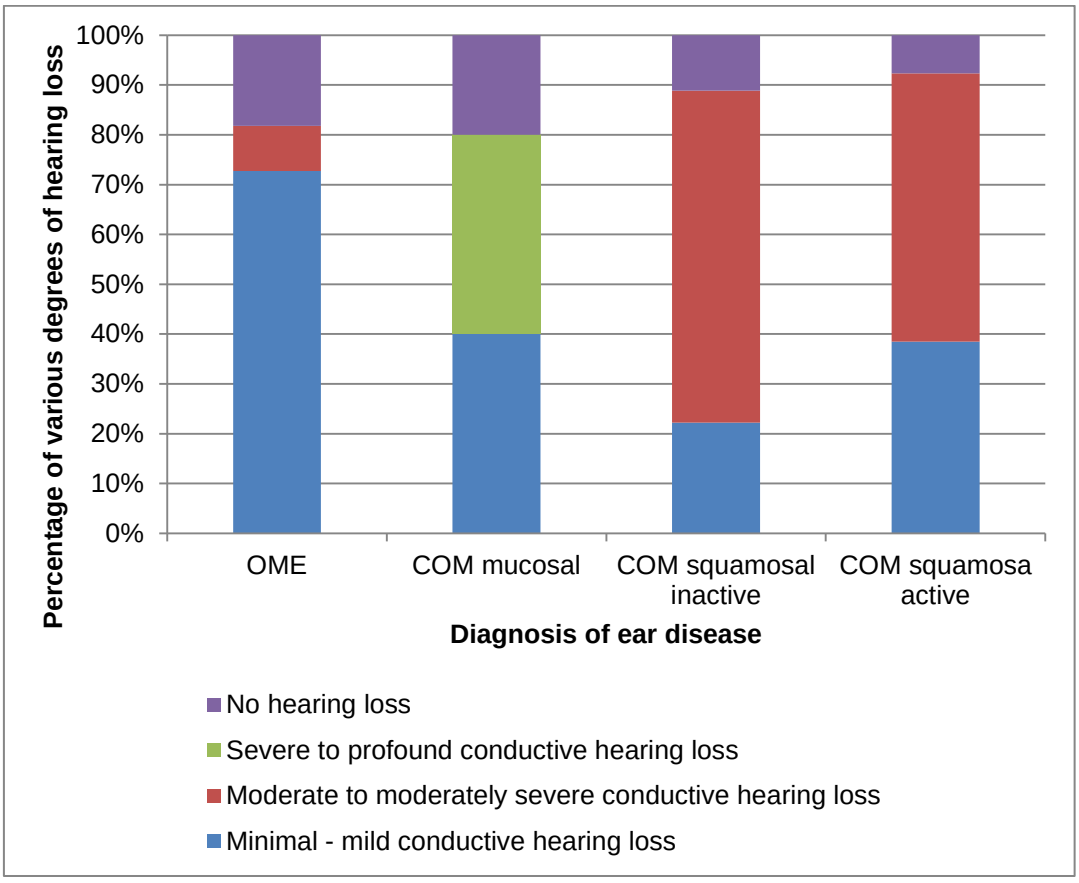


Figure 17: Distribution of various degrees of hearing loss in the different ear diseases

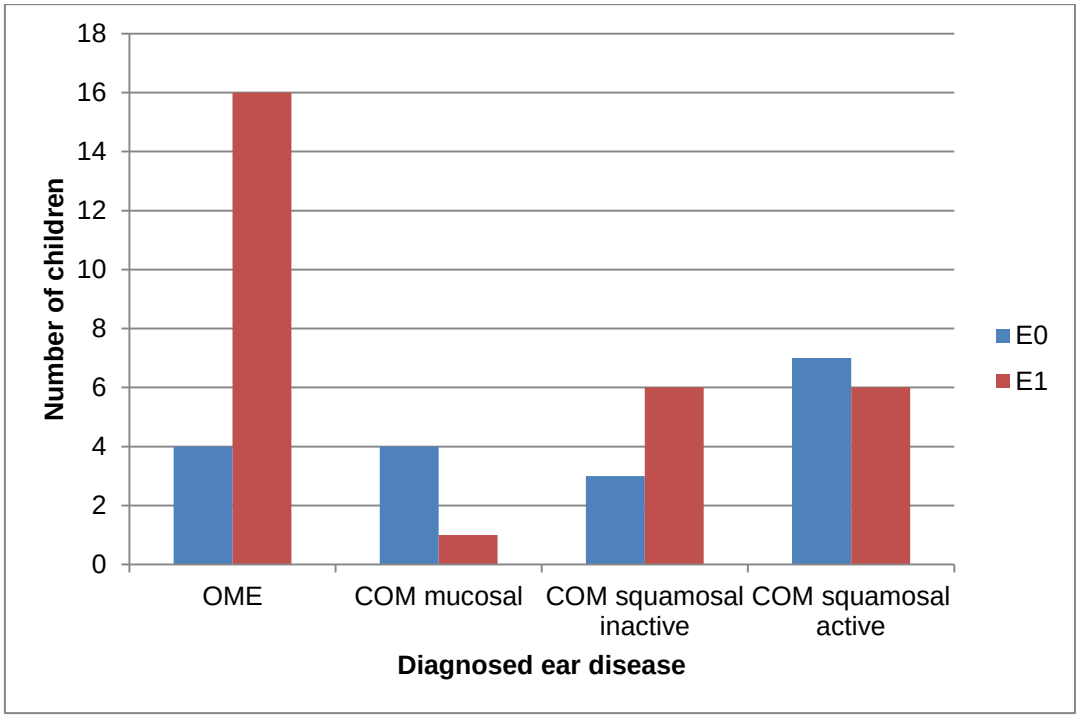


Figure 18: Correlation between the various ear diagnoses and the presence of Eustachian tubal block based on 'E' grade of theatre grading

III. Analysis of grading system

III.1 Inter-rater and intra-observer reliability of A.C.E. grading system

For the assessment of inter-rater and intra-rater reliability, the first or baseline grading and the second grading (given after an interval of at least three weeks) provided by each rater for each patient was compared. This comparison was done individually for the 'A', 'C' and 'E' components. Based on this, the Cronbach's alpha and the intra-class correlation coefficient were obtained. The results for the 'A' component are given below.

Table 6: Cronbach's alpha and intra-class correlation coefficient for individual raters for 'A' grade

	Cronbach's alpha	Intraclass correlation coefficient			p value
		ICC	95% confidence interval		
			Lower bound	Upper bound	
Rater 1	0.835	0.835	0.764	0.884	<0.01
Rater 2	0.827	0.827	0.753	0.879	<0.01
Rater 3	0.813	0.813	0.733	0.869	<0.01

Table 7: Overall Cronbach's alpha and intra-class correlation coefficient for 'A' grade

	Cronbach's alpha	Intraclass correlation coefficient			p value
		ICC	95% confidence interval		
			Lower bound	Upper bound	
At baseline	0.827	0.827	0.767	0.874	<0.01
After 3 weeks	0.810	0.810	0.744	0.862	<0.01

Cronbach's alpha and intra-class correlation coefficient were calculated for the 'C' component and are given below.

Table 8: Cronbach's alpha and intra-class correlation coefficient for individual raters for 'C' grade

	Cronbach's alpha	Intraclass correlation coefficient			p value
		ICC	95% confidence interval		
			Lower bound	Upper bound	
Rater 1	0.730	0.730	0.615	0.811	<0.01
Rater 2	0.836	0.836	0.766	0.885	<0.01
Rater 3	0.687	0.687	0.553	0.780	<0.01

Table 9: Overall Cronbach's alpha and intra-class correlation coefficient for 'C' grade

	Cronbach's alpha	Intraclass correlation coefficient			p value
		ICC	95% confidence interval		
			Lower bound	Upper bound	
At baseline	0.797	0.797	0.727	0.852	<0.01
After 3 weeks	0.736	0.736	0.644	0.807	<0.01

For the 'E' component, McNemar's χ^2 test was performed instead of the Cronbach's alpha and ICC – this was because the 'E' component is a binomial variable and Cronbach's alpha and ICC are performed for polynomial variables. Based on the χ^2 test, the p value was calculated. The results are given below.

Table 10: McNemar's χ^2 test results for 'E' grade

	p value
Rater 1	0.120
Rater 2	<0.01
Rater 3	0.058

The baseline or first grade given by each rater was also compared with the theatre grade in order to further assess inter-rater reliability. The theatre grade was taken as the gold standard. This comparison was done individually for the 'A', 'C' and 'E' components. The results for the 'A' component are as follows.

Table 11: Comparison between baseline 'A' grade of individual raters and the standard grade

	Cronbach's alpha	Intraclass correlation coefficient			p value
		ICC	95% confidence interval		
			Lower bound	Upper bound	
Rater 1	0.755	0.755	0.651	0.828	<0.01
Rater 2	0.741	0.741	0.631	0.819	<0.01
Rater 3	0.728	0.728	0.612	0.809	<0.01

This comparison with Cronbach's alpha and ICC was done for the 'C' component also and the results are as below.

Table 12: Comparison between baseline 'C' grade of individual raters and the standard grade

	Cronbach's alpha	Intraclass correlation coefficient			p value
		ICC	95% confidence interval		
			Lower bound	Upper bound	
Rater 1	0.627	0.627	0.465	0.740	<0.01
Rater 2	0.724	0.724	0.605	0.807	<0.01
Rater 3	0.599	0.599	0.426	0.720	<0.01

The same comparison between theatre grade and baseline grade of the raters was done for the 'E' component. The results are described below.

Table 13: Comparison between baseline 'E' grade of individual raters and the standard grade

	Cronbach's alpha	Intraclass correlation coefficient			p value
		ICC	95% confidence interval		
			Lower bound	Upper bound	
Rater 1	0.589	0.589	0.412	0.713	<0.01
Rater 2	0.722	0.722	0.602	0.806	<0.01
Rater 3	0.619	0.619	0.454	0.734	<0.01

The inter-rater agreement between raters 1 and 2 was assessed by calculating Kappa values for the individual ‘A’, ‘C’ and ‘E’ grades. The results for the ‘A’ component are as follows.

Table 14: Inter-rater agreement for all raters for ‘A’ grade

	Observed agreement (%)	Expected agreement (%)	Kappa	Kappa - 95% confidence interval	Z - statistic	p value
Rater 1 vs. Rater 2	87.097	75.802	0.467	0.35 – 0.583	8.222	<0.001
Rater 1 vs. Rater 3	84.409	75.789	0.356	0.239 – 0.473	7.029	<0.001
Rater 2 vs. Rater 3	73.656	68.032	0.176	0.108 – 0.244	5.11	<0.001

Kappa was calculated for the ‘C’ component to assess agreement. The results are given below.

Table 15: Inter-rater agreement for all raters for ‘C’ grade

	Observed agreement (%)	Expected agreement (%)	Kappa	Kappa - 95% confidence interval	Z - statistic	p value
Rater 1 vs. Rater 2	82.61	70.35	0.415	0.297 – 0.533	6.546	<0.001
Rater 1 vs. Rater 3	93.145	82.564	0.607	0.443 – 0.771	6.918	<0.001
Rater 2 vs. Rater 3	82.258	70.669	0.395	0.287 – 0.503	6.267	<0.001

Kappa was also calculated for the ‘E’ component and the results are as follows.

Table 16: Inter-rater agreement for all raters for ‘E’ grade

	Kappa	Standard error	p value
E (rater 1 vs. rater 2)	0.524	0.073	<0.01
E (rater 1 vs. rater 3)	0.450	0.091	<0.01
E (rater 2 vs. rater 3)	0.454	0.081	<0.01

III.2 Correlation between A.C.E. grading done in the operation theatre versus the grading done in the out-patient department

The grading obtained in the theatre, considered as the standard grading, was compared with the grading obtained in the out-patient department in order to calculate the Cronbach's alpha and the intra-class correlation coefficient to assess the reliability of the grading system for use in the out-patient department. The values are given below.

Table 17: Cronbach's alpha and ICC for the A.C.E. grading compared between the standard grade and the OPD grade

	Cronbach's alpha	Intraclass correlation coefficient			p value
		ICC	95% confidence interval		
			Lower bound	Upper bound	
'A' grade	0.667	0.667	0.488	0.783	<0.01
'C' grade	0.763	0.763	0.631	0.848	<0.01
'E' grade	0.788	0.788	0.670	0.864	<0.01

DISCUSSION

The children planned for adenoidectomy were graded according to the ACE grading and evaluated. The clinical presentation of adenoid hypertrophy noted in the study matched published descriptions.

The children usually presented between the ages of 4 years and 9 years, which was when the mismatch between the adenoid volume and nasopharyngeal volume was maximum.

Majority of the children (81%) presented with features of adenoid hypertrophy without otitis media with effusion. This included chronic adenoid hypertrophy, chronic adenotonsillitis and chronic adenoid hypertrophy alone. The remaining 19% had adenoid hypertrophy with otitis media with effusion.

The most common symptoms at presentation included mouth breathing, snoring and nasal obstruction. This reflects the effect of adenoid enlargement on nasal airflow.

The presence of sleep disordered breathing was significantly correlated with the presence of choanal obstruction and the higher grades of adenoid hypertrophy. 73% of the patients with sleep disordered breathing had higher adenoid grades (A3 and A4). Similarly, 89% of the children with sleep disordered breathing had some degree of choanal obstruction (grades C1 and C2), with 64.5% having more than 50% choanal obstruction (grade C2). Of the patients with grade C1 or C2 adenoids, at least 79% had complaints of sleep disordered breathing. This showed a high degree of association between the presence of large volume adenoids and choanal obstruction with sleep disordered breathing.

66% of the patients with chronic adenotonsillitis had grade 3 and 4 adenoid enlargement, while 33% of the patients had grade 1 and 2 adenoid. Thus majority of the patients with infection had enlarged adenoids.

In relation to ear examination, 52.4% of the children showed presence of dull tympanic membrane, while 25% had tympanic membrane retraction. In contrast, perforation of the tympanic membrane and cholesteatoma were less prevalent.

The presence of otitis media with effusion was significant in the presence of Eustachian tubal block (E1 grade), as was the presence of chronic otitis media squamosal inactive disease. This shows the likely role of Eustachian tube obstruction in the pathogenesis of these conditions. Chronic otitis media mucosal disease and cholesteatoma did not seem related to the presence of Eustachian tubal block. The number of children with mucosal disease was too small to observe any correlation.

Investigation showed normal hearing in the majority of the patients (54%).

Analysis of the tympanometry curves showed that the type ‘B’ and type ‘C’ tympanograms were approximately 8% more common in children with Eustachian tubal dysfunction as diagnosed by an E1 grade on theatre grading.

On comparison of the degree of hearing loss in the various ear diagnoses, an expected correlation between minimal and mild conductive hearing loss and otitis media with effusion was noted. Moderate to severe hearing loss was more prevalent in the presence of cholesteatoma or chronic otitis media inactive squamosal disease. However, 2 children with chronic otitis media mucosal disease had profound hearing loss, which could not be explained by the Eustachian tubal block or the tympanic

membrane perforation alone. This was probably related to other factors related to the tympanic membrane perforation, which had not been enumerated.

On comparison of the adenoid grading obtained from X-ray nasopharynx with the adenoid grade obtained endoscopically, there was only about 54% correlation. This ranged from 45% for A1 adenoids, 65% for A2 adenoids, to 50-55% for A3 and A4 adenoids. This showed that rigid endoscopy was a better tool for assessing adenoid hypertrophy than radiography, especially since radiographs tended to underestimate the lower levels of adenoid enlargement.

In order to assess the usefulness of the A.C.E. grading system, three parameters were calculated. The Cronbach's alpha and intra-class correlation coefficient helped in assessing the inter-rater reliability and the internal consistency, and the intra-class correlation coefficient also measured the consistency. Agreement was calculated using the Kappa statistic. Of the raters, raters 1 and 2 were consultants with a minimum of 5 years' experience, while rater 3 was a post-graduate student with one year's experience in nasal endoscopy.

The Cronbach's alpha looks at the extent to which the variables consistently measure a concept.

The intra-class correlation coefficient reflects both the inter-observer and intra-observer variability, and measures the consistency of the measurements made by multiple raters or observers when measuring the same quantity.

The Kappa statistic measures the observed agreement between raters and assesses the

agreement arising out of chance.

Intra-rater variability

For the ‘A’ variable of the A.C.E. grading system, the overall Cronbach’s alpha and intra-class correlation coefficient for all raters were 0.827 and 0.810 respectively at baseline and after 3 weeks. This implies good consistency in measuring the adenoid size for the raters. There was no significant difference when comparing the more experienced raters 1 and 2 with the less experienced rater 3, showing that it was an easy and a replicable way of grading.

For the ‘C’ variable of the A.C.E. grading system, the overall Cronbach’s alpha and intra-class correlation coefficient for all raters were 0.797 and 0.736 respectively at baseline and after 3 weeks. This also showed good consistency in measuring the degree of choanal obstruction. Although there was a small difference in the Cronbach’s alpha for individual raters, with rater 3 scoring the lowest with an alpha of 0.687, this was still within the range for good consistency and reliability.

For the ‘E’ variable of the A.C.E. grading system, the McNemar’sχ^2 test was used since it was a paired binomial variable. The results showed discordance for raters 1 and 3, but good consistency for rater 2. This could be due to the poor quality of the images used for grading. In addition to being two-dimensional and missing the dynamic component of Eustachian tube opening, the extent to which the photographs showed the Eustachian tube orifice was limited and this may have made it difficult to interpret the patency of the Eustachian tube.

Comparison of individual raters with the standard grade

When comparing the individual raters' grades with the theatre grade, the results were good for the 'A' variable, with both Cronbach's alpha and intra-class correlation coefficient being more than 0.7.

For the 'C' variable, rater 2 showed results which were well consistent with the theatre grade, however rater 1 and rater 3 showed poorer consistency, although it was still significant. This probably reflects a need for more training and familiarity with the grading system to ensure better consistency and to minimize the measurement error.

For the 'E' variable also, the results were similar to those for the 'C' variable, with good consistency for rater 2 and poorer consistency for rater 1 and rater 2. This again indicates the need for more training in the use of the grading system. This could also be due to the limited number of options in the 'E' variable, which could lead to falsely low Cronbach's alpha values.

Inter-rater variability

The inter-rater agreement was assessed using the Kappa statistic. For the 'A' variable, Kappa showed moderate agreement between raters 1 and 2 which was not due to chance. Between rater 1 and rater 3, there was fair agreement, and between rater 2 and 3 there was only slight agreement. This showed that there was significant improvement in the agreement between the raters when the level of experience improved. This could also be due to a tendency among the raters to identify one group

in the variable more than the others.

For the ‘C’ variable, agreement between all the raters was fair to moderate, with Kappa ranging between 0.395 and 0.607.

For the ‘E’ variable, there was moderate agreement between all raters, which was sufficient for clinical application.

Comparison of the OPD grading with the standard theatre grade

On comparison of the grading obtained in the out-patient department (OPD) with the theatre grade, a good correlation was noted. Both Cronbach’s alpha and intra-class correlation coefficient were significant for all three variables. This indicated that the grading system was replicable in the OPD and could be used for evaluating patients in the out-patient department, which is clinically relevant.

CONCLUSION

The A.C.E. endoscopic adenoid grading system is a useful tool in the assessment of adenoid hypertrophy and its description.

The inter-rater reliability was good for all the variables of the A.C.E. grading system. There was a good reliability and moderate agreement between all the three raters using this grading system. Intra-rater reliability was best for the ‘A’and ‘C’ components. There was an improvement in the inter-rater reliability with experience. The variables correlated well between the standard grade and the out-patient grade. Thus, the grading system can be used in the clinical setting as well. The components of the grading system correlate well with the presence of various symptoms in the patient.

Among the limitations of the study was the small sample size (124) as against the calculated 205 patients. With a higher number of patients, we expect the reliability to improve. Hence, the study will be continued in order to accrue more patients and to reassess the reliability and agreement with a larger number of patients.

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PARENT INFORMATION SHEET

STUDY: RELIABILITY OF ACE GRADING SYSTEM OF ADENOIDS

What are adenoids?

Adenoids are a mass behind the nose, present in all children. It can become big in some children and cause problems, including nose block, runny nose, sneezing, throat pain, ear pain and decreased hearing. This can affect the child's development and cause other health problems. If your child comes to the hospital with any of the complaints mentioned above, he/she will undergo some tests to see if the adenoids are enlarged. A thin telescope will be placed in the nose to see the adenoids and the size will be assessed.

What is the study about?

The size of the adenoids can be graded in several ways. We have developed a system using endoscopy. We will assess how different doctors use the grading system and see whether they agree.

What is my child's participation?

When your child is being evaluated in OPD before the surgery, we will do an endoscopy to see the adenoid grade. We will also do endoscopy during the operation and again check the adenoid grade.

What are the risks to my child if he/she participates in the study?

There will be some minimal discomfort to the child when the endoscope is placed in the nose. Occasionally, there may be a little bleeding, which will usually settle with nose drops.

What is the benefit to my child?

There is no particular benefit to the child.

What is the benefit to others?

If the grading system is consistent when used by different people, it will help in assessing other children with adenoids and in planning treatment.

Confidentiality

Your child's identity or any identifiable characteristics will not be revealed and only the results of the study will be published in a scientific journal.

Participation

Your child's participation in the study is strictly voluntary, and you are free to withdraw at any time without giving a reason. Your treatment will not be affected by whether you participate or not in the study.

For any doubts or clarifications, please contact:

Dr. Joby Ninan,
Department of ENT unit 2,
CMC, Vellore
Mobile: 9786929671
Office: 04162282798

Signature or thumb impression of the parent or guardian:

Name of the parent or guardian and relationship to the subject: _____

Signature of the investigator:

Date: __/__/__

INFORMED CONSENT

STUDY TITLE: To assess the reliability of ACE grading system of adenoids.

SUBJECT'S NAME:

HOSPITAL NUMBER:

1. I confirm that I have read and understood the information sheet for the above study and have had the opportunity to ask questions.
2. I understand that my child's participation in the study is voluntary and that he/she is free to withdraw at any time, without giving any reason. His/her medical care will not be affected in any way.
3. I understand that the Ethics Committee and the regulatory authorities will not need my permission to look at my child's health records with respect to the current study and any further research that may be conducted in relation to it, even if we withdraw from the trial. I agree to this access. I understand that my child's identity will not be revealed in any information released to third parties or published.
4. I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purposes.
5. I agree to let my child take part in the above study.

Signature or thumb impression of the subject:

Signature or thumb impression of the parent or guardian:

Name of the parent or guardian and relationship to the subject: _____

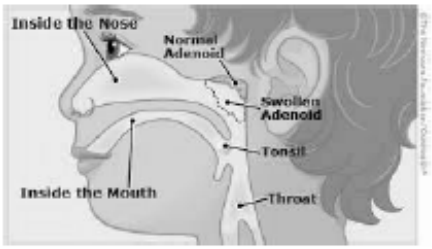
Signature of the investigator:

Date: __/__/__

CHILD INFORMATION SHEET

STUDY: To assess the reliability of ACE grading system of adenoids

Hello! We are doing a study to see the reason why you are having nose, ear or throat problems.



We will need to ask you some questions, and do some tests to see inside your nose. This may cause a little discomfort, but we will try to make it as comfortable as possible.
You can ask questions about your condition. If at any time you decide that you do not want to take part in the study, you can do so. If you sign this paper, it means that you agree to be a part of this study. Even if you sign it now, you can change your mind at any time if you wish so.

Your signature / thumb impression:

Parent's or Guardian's signature / thumb impression:

Investigator's name and signature:

Date: __/__/__

ASSENT

STUDY: To assess the reliability of ACE grading system of adenoids

Hello! We are doing a study to see the reason why you are having nose, ear or throat problems. We will need to ask you some questions, and do some tests to see inside your nose. This may cause a little discomfort, but we will try to make it as comfortable as possible.

You can ask questions about your condition. If at any time you decide that you do not want to take part in the study, you can do so.

If you sign this paper, it means that you agree to be a part of this study. Even if you sign it now, you can change your mind at any time if you wish so.

Your signature / thumb impression:	
Parent's or Guardian's signature / thumb impression:	
Investigator's name and signature:	

Date: __/__/__

DATA COLLECTION SHEET

NAME: HOSPITAL NUMBER: □□□□□□

AGE: □□ GENDER: Male (1) □ / Female (2) □

FATHER'S NAME: STUDY ID: □□□□ / □□□□ / □□□□

ADDRESS:

HISTORY: (Please tick the applicable)

	PRESENT (1)	DURATION	ABSENT (2)
Nose block			
Mouth breathing			
Snoring			
Recurrent colds			
Hearing loss			
Ear pain			
Ear discharge			
Throat pain with fever			

EXAMINATION: (Please tick the applicable)

	PRESENT		ABSENT	
Mouth breathing				
Dull tympanic membrane	Rt	Lt	Rt	Lt
Retracted tympanic membrane	Rt	Lt	Rt	Lt
Tympanic membrane perforation	Rt	Lt	Rt	Lt
Glue ear	Rt	Lt	Rt	Lt
Nasal discharge				
Enlarged tonsils				
Tympanogram 'B'	Rt	Lt	Rt	Lt
Tympanogram 'C'	Rt	Lt	Rt	Lt
Audiogram with conductive hearing loss	Rt	Lt	Rt	Lt
Xray nasopharynx	1 / 2 / 3 / 4			

ADENOID GRADING: (Please circle the appropriate)

	A_1	C_1	E_1	A_2	C_2	E_2
Rater 1 (Consultant)	0 / 1 / 2 / 3 / 4	0 / 1 / 2	0 / 1	0 / 1 / 2 / 3 / 4	0 / 1 / 2	0 / 1
Rater 2 (Consultant)	0 / 1 / 2 / 3 / 4	0 / 1 / 2	0 / 1	0 / 1 / 2 / 3 / 4	0 / 1 / 2	0 / 1
Rater 3 (PG)	0 / 1 / 2 / 3 / 4	0 / 1 / 2	0 / 1	0 / 1 / 2 / 3 / 4	0 / 1 / 2	0 / 1
Theatre grade	0 / 1 / 2 / 3 / 4	0 / 1 / 2	0 / 1			
OPD grading	0 / 1 / 2 / 3 / 4	0 / 1 / 2	0 / 1			

Name	Age	Sex	Nose block	Mouth breathing	Snoring	Recurrent URI	Sneezing	Hearing loss	Ear pain	Ear discharge	Sore throat	Dull TM	Side	Retracted TM	Side	COM sq active	Side	TM hole	Side	Glue ear	Side	Nasal discharge	Tonsil	Tymp 'B'	Side	Tymp 'C'	Side	CHL	Side	X-ray nasophnx
Allwyn	9	1	1	1	1	1	1	0	0	0	0	0		0		0		0		0		1	0	0		0		0		0
Dharshan	4	1	1	1	1	0	0	0	0	0	1	0		0		0		0		0		0	1	0		1	3	0		4
Salman	11	1	1	1	1	0	0	0	0	0	1	1	3	0		0		0		0		0	1	0		0		0		2
Ram	6	1	1	1	1	1	0	0	0	0	1	0		0		0		0		0		0	1	0		0		0		3
Mohd Rumi	8	1	1	1	1	0	0	1	0	1	1	0		1	1	1	1	0		0		0	1	1	1	0		1	1	
Hethvi	3	2	1	1	1	1	0	1	0	0	0	1	3	0		0		0		1	3	0	1	0		1	3	1	3	2
Janhvi	4	2	1	1	1	1	1	0	0	0	0	0		0		0		0		0		0	1	0		1	3	0		4
Dhanusha	5	2	0	1	1	0	0	0	0	0	1	0		0		0		0		0		0	1	0		0		0		4
Siddhani	7	2	1	1	0	1	0	0	1	0	0	1	3	0		0		0		0		0	1	0		0		0		
Chris	12	1	1	1	1	0	0	0	0	0	1	0		0		0		0		0		0	1	0		0		0		
Aman	16	1	1	0	0	1	0	1	1	1	0	0		1	2	1	2	1	2	0		0	0					1	2	
Aradhana	7	2	1	1	1	1	0	0	0	0	0	1	3	0		0		0		1	3	0	1	1	1	1	2	1	3	2
Krish	11	1	0	0	0	1	0	1	0	1	0	0		1	1	0		1	2	0		0	1	1	1	0		1	2	
Aameena	6	2	1	1	1	0	0	0	0	0	1	0		0		0		0		0		0	1	0		0		0		
Prem	13	1	0	1	0	1	1	1	1	0	0	1	3	1	3	0		0		0		0	1	0		1	3	1	1	
Hareesh	7	1	0	0	0	1	1	1	1	1	0	1	1	1	2	0		0		1	2	0	1	0		1	3	1	2	2
Tanbeer	5	1	1	1	1	1	1	0	0	0	1	0		0		0		0		0		0	1	0		0		0		3
Tejash	6	1	1	1	1	1	0	0	0	0	1	0		0		0		0		0		0	1	0		0		0		2
Bhowya	12	2	0	1	1	1	0	0	0	0	1	0		0		0		0		0		1	1	0		0		0		
Satyam	3	1	1	1	1	1	0	0	0	0	0	1	3	0		0		0		1	3	1	1	0		1	3	1	3	4
Soumodip	12	1	0	1	1	0	0	1	0	1	0	1	1	1	3	1	2	0		1	3	0	1	0		1	3	1	3	2
Rajib	9	1	1	1	1	1	0	1	0	0	1	1	3	0		0		0		0		0	1	0		1	3	0		3
Yuvaraman	4	1	1	1	1	1	0	0	0	0	1	0		0		0		0		0		1	1	0		1	2	0		2
Subhodeep	9	1	0	1	1	0	0	1	1	1	0	1	3	1	3	0		0		0		0	1	0		1	3	1	3	4
Shrijani	5	2	1	1	1	1	1	0	0	0	0	1	3	0		0		0		1	3	1	0	1	3	0		1	3	2

Mounish	4	1	1	1	1	1	0	0	0	0	0	1	2	0		0		0		1	2	1	1	1	2	0				3
Sulochana ’s baby	6	1	1	1	1	0	0	0	0	0	0	1	3	0		0		0		0		1	1	0		1	3	0		4
D.K. Singh	8	1	1	1	1	1	0	1	0	1	0	1	3	1	3	0		0		0		0	1	1	3	0		1	3	2
Pratim	14	1	1	1	1	1	0	0	0	0	1	0		0		0		0		0		0	1	0		0		0		4
Gopika	5	2	1	1	1	1	0	0	0	0	0	0		0		0		0		0		0	1	0		0		0		3
Swastika	7	2	1	1	1	1	0	0	0	0	1	0		0		0		0		0		1	1	0		0		0		4
Anuj	6	1	0	1	0	0	0	0	0	1	0	0		0		1	1	1	1	0		0	0					1	3	2
Aniket	12	1	1	1	1	1	0	0	0	0	1	0		0		0		0		0		0	1	0		1	3	0		4
Neeranjan	4	1	0	0	0	1	0	0	0	0	1	0		0		0		0		0		0	1	0		1	2	1	3	2
Abhishek	13	1	0	1	1	1	1	0	0	0	1	0		0		0		0		0		0	1	0		0		0		
Sumona	12	2	1	1	1	1	1	0	0	0	1	0		0		0		0		0		0	1	0		0		0		
Aninda	15	1	0	0	0	0	0	1	0	1	0	1	3	1	3	0		1	2	0		0	0					0		
Mohd Zaid	12	1	0	0	0	0	0	0	0	1	0	0		0		1	1	0		0		0	0					1	1	
Rounak	6	1	1	1	1	1	1	0	0	0	1	0		0		0		0		0		0	1	0		0		0		3
Suryansh	7	1	1	1	1	1	1	0	0	0	1	1	3	0		0		0		0		0	1	0		0		0		
Aarav	3	1	1	1	1	0	0	0	0	0	0	1	3	0		0		0		0		1	1							3
Mohan	8	1	1	1	1	1	1	0	0	0	0	1	3	0		0		0		1	3	1	1	1	3	0		1	1	3
Prince	4	1	1	1	1	1	1	0	0	0	1	1	3	0		0		0		0		1	1	0		0		0		3
Thangarasu	4	1	0	1	1	1	0	0	0	0	1	1	3	0		0		0		0		1	1	1	3	0		0		4
Rudra	4	1	1	1	1	1	0	0	0	0	0	0		0		0		0		0		0	1	0		1	3	1	3	
Jeronima	6	2	1	0	0	1	0	0	0	0	1	0		0		0		0		0		0	1	0		1	1	0		3
Aakash	5	1	1	1	1	0	0	0	0	0	1	0		0		0		0		0		0	1	0		1	2	0		3
Mohd Rizwan	8	1	0	1	0	1	1	0	0	0	1	0		0		0		0		0		0	1	0		0		0		
Sumithra	13	2	1	1	0	1	1	0	0	0	1	1	3	1	3	0		0		1	3	0	1	0		0		1	3	2
Tushar	4	1	1	0	0	1	0	1	1	0	1	0		0		0		0		0		0	1	0		0		0		4
Prannav	6	1	1	1	1	1	0	0	0	0	1	0		0		0		0		0		0	1	0		0		0		
Harsh	9	1	1	1	1	1	1	0	0	0	0	1	3	0		0		0		0		1	1	0		0		0		
Sarthak	9	1	1	0	0	1	0	1	0	1	1	1	3	1	3	1	2	1	2	0		1	1	0		1	3	1	3	1
Zareen	7	2	1	1	1	1	0	0	0	0	1	0		0		0		0		0		1	1	0		0		0		

Utshow	5	1	1	1	1	1	0	0	0	0	1	1	3	1	3	0		0		0		1	1	0		1	2	0		3							
Prince	13	1	0	0	0	1	1	0	0	0	1	0		0		0		0		0		0	1	0		0		0									
Parvaj	6	1	1	1	1	1	0	0	0	0	1	1	3	0		0		0		0		0	1	0		1	3	0									
Arghyadip	5	1	1	1	1	0	0	0	1	0	1	1	3	0		0		0		0		0	1	0		0		0		3							
Asmi	6	2	1	0	0	1	1	0	0	0	1	0		0		0		0		0		0	1	0		1	1	0		2							
Anuska	6	2	1	1	1	1	0	0	0	0	1	0		0		0		0		0		0	1	0		0		0		4							
Rishab	5	1	0	1	1	0	0	1	1	1	0	0		0		1	3	0		0		1	1	1	1	0		1	2	3							
Affreen	10	2	1	0	0	1	1	1	0	1	1	1	3	1	1	1	1	0		0		0	1	0		1	1	1	3								
Biswarup	10	1	1	0	0	0	0	0	0	0	1	1	3	0		0		0		0		1	1	0		0		0		2							
Snighda	11	2	1	1	1	1	1	1	0	0	0	1	3	1	1	0		0		1	2	0	1	1	3	0		1	3								
Lokesh	6	1	0	0	0	0	0	0	1	1	1	0		0		0		1	2	0		0	1	0		0		1	2	3							
Shariar	13	1	1	1	1	1	1	1	1	1	0	1	3	1	3	1	2	0		0		0	0														
Rainesh	11	1	1	1	0	1	1	0	0	0	1	0		0		0		0		0		0	1														
Ram	13	1	1	1	1	1	1	1	1	0	0	1	3	1	3	0		0		1	1	0	1	0		0		1	1								
Aditya	3	1	1	1	1	1	1	0	0	0	0	0		0		0		0		0		0	1														
Prem	13	1	0	0	0	1	1	1	0	1	0	1	1	1	2	1	2	0		0		1	1	1	2	0		1	2								
Sandya	5	2	0	0	1	1	0	0	0	0	1	0		0		0		0		0		0	1	0		0		0		2							
Graham	6	1	1	1	1	1	1	0	0	0	1	0		0		0		0		0		0	1	0		0		0		1							
Safia	3	2	1	1	1	1	0	0	0	0	1	0		0		0		0		0		1	1	0		0		0									
Sameena's baby	5	1	1	1	1	1	0	0	0	0	1	1	3	1	3	0		0		0		0	1	0		1	3	1	3								
Gopinath	9	1	0	1	1	1	0	1	0	1	1	1	1	1	1	0		1	2	0		0	1	0		0		1	2	2							
Tejas	4	1	1	1	1	1	0	0	0	0	1	0		0		0		0		0		1	1	0		0		0		2							
Sanjay	4	1	1	1	1	1	0	0	0	0	1	1	3	1	3	0		0		0		1	1	0		0		0		3							
Rimjhim	10	1	1	1	1	1	1	0	1	0	1	0		0		0		0		0		0	1	0		0		0		3							
Hemasree	4	2	1	1	1	1	1	0	0	0	1	0		0		0		0		0		0	1	0		1	2	0		1							
Ananya	4	2	1	1	1	1	1	0	0	0	1	1	3	0		0		0		1	3	1	1	0		1	2	1	3	3							
Sandy	4	1	1	1	1	1	0	0	1	0	0	1	3	0		0		0		0		1	1	1	3	0		1	3	3							
Sanjeetha	6	2	1	1	1	0	0	0	0	0	1	1	3	0		0		0		1	3	1	1	1	1	1	2	0									
Srinithi	10	2	0	1	1	1	1	0	0	0	1	1	3	0		0		0		0		0	1	0		0		1	1	2							

Lithesh	4	1	0	1	1	1	0	0	1	0	0	1	3	1	3	0		0		1	3	0	1	1	1	1	2	1	1	3
Mohd Mudasir	5	1	0	1	1	0	0	0	0	0	1	0		0		0		0		0		1	1	0		0		0		4
Divya	4	2	1	1	1	1	1	0	1	0	1	1	3	0		0		0		1	3	1	1	1	3	0		1	3	3
Giri	6	1	1	1	1	1	1	0	0	0	0	1	3	1	3	0		0		0		1	1	0		0		0		3
Naren	7	1	0	1	1	0	0	1	0	1	0	1	3	0		0		0		1	3	0	0	1	3	0		1	3	3
Hrishikesh	4	2	1	1	1	1	0	0	0	0	1	0		0		0		0		0		0	1	0		0		0		4
Milind	7	1	0	1	1	1	1	1	0	0	0	0		0		0		0		0		1	1	0		0		1	3	4
Jeet	9	1	0	1	1	1	0	1	0	0	0	1	3	0		0		0		1	3	0	0	0		1	3	1	3	2
Pabitra	10	1	1	0	0	1	1	1	0	1	0	0		0		0		1	3	0		0	0					1	3	
Chandana	12	2	0	0	0	0	0	1	0	0	0	1	3	1	3	0		0		0		0	0	0		1	3	1	3	3
Pritam	9	1	0	0	0	0	0	1	1	0	1	0		0		0		0		0		0	1	0		0		0		
Ankan	13	1	1	1	0	1	0	1	0	1	0	1	3	1	3	1	3	0		0		1	1					1	3	1
Turjya	7	1	1	1	1	1	1	0	0	0	1	1	3	0		0		0		1	3	1	1	1	2	1	1	1	3	4
Sushmita	6	2	1	1	1	0	0	0	0	0	1	0		0		0		0		0		0	1							1
Percia	10	2	0	1	1	0	0	0	0	1	0	1	3	1	3	0		0		0		0	1	1	3	0		1	1	
Mohd Karamot	4	1	1	1	1	0	1	0	0	0	1	0		0		0		0		0		0	1	0		0		0		3
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Ojas	5	1	1	1	1	1	1	0	0	0	0	1	3	0		0		0		0		0	0	0		1	3	1	3	3
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Sam	9	1	1	1	1	1	0	0	0	0	1	0		0		0		0		0		0	1	0		1	1	1	1	2
Prithi	9	2	1	1	1	1	1	1	1	0	0	1	3	0		0		0		0		1	1	0		0		1	3	
Altamas	5	1	1	1	1	1	0	1	1	0	0	1	3	1	3	0		0		1	3	0	1	1	3	0		1	3	
Deepa's baby	4	1	1	1	1	1	0	0	0	0	0	1	3	0		0		0		1	3	1	1	0		0		0		3
Deeraj	6	1	1	1	1	1	0	0	0	0	1	1	3	0		0		0		0		0	1	0		0		0		3

Hanniel	5	1	1	1	1	1	1	0	1	0	1	1	3	0		0		0		0		0	1	0		1	2	0		3			
Sathyan	8	1	1	0	0	1	1	1	0	1	0	0		1	2	1	2	0		0		0	0					1	2	2			
Kanimozhi	5	2	1	1	1	1	1	0	0	0	1	1	3	0		0		0		0		1	1	1	1	1	2	0		2			
Masroora	5	2	1	1	1	1	1	0	0	0	1	0		0		0		0		0		1	1	0		1	3	1	3	3			
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Gulam	5	1	1	1	1	1	1	1	1	0	1	1	3	0		0		0		1	3	1	1	0		1	3	1	3				
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Shail	11	1	1	1	1	1	0	0	0	0	1	0		0		0		0		0		0	1										
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Jovan	4	1	1	1	1	1	0	0	1	0	1	0		0		0		0		0		1	1	0		1	3	0		4			

Adenoid11	Adenoid12	Choana11	Choana12	ETO11	ETO12	Adenoid21	Adenoid22	Choana21	Choana22	ETO21	ETO22	Adenoid31	Adenoid32	Choana31	Choana32	ETO31	ETO32	Adenoidot	Choanaot	ETOot	Adenoidopd	Choanaopd	ETOopd
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