CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY IN GENERAL

Sore throat (tonsillitis) involves viral or bacterial inflammation of tonsils. It manifests in acute or chronic state and usually accompanied with hypertrophic adenoids particularly in pediatric population (Alkadem, Salim, & Al-Kerttani, 2018). Acute tonsillitis is the inflammation of one or both tonsillar tissue along with fever, malaise, odynophagia, swelling and hyperemia of these structures. It may be associated with exudate or cervical lymphadenopathy (Timo, 2015). It is usually viral in origin and may occur in epidemic form superimposed by bacterial infection most commonly beta hemolytic streptococcus. Staphylococci, Pneumococci, Hemophilus Influenza and Moraxella Catarrhalis are also involved in the pathogenesis of the condition (Udaipurwala, 2017). Whereas chronic infection comprises recurrence of acute attacks usually 5 or more attacks of true tonsillitis in a year and persistence of symptoms for about twelve months which includes chronic throat discomfort, pain, enlarged tonsils, palpable tender jugulo diagastric lymph nodes and foetor oris (Pichichero, 1995).

Enlargement of pharyngeal tonsil which are localized in the middle of nasopharynx causes occlusion of nasopharynx, middle ear infection, chronic middle ear fluid and adenoid facies (Millington & Phillips, 2014). Scanty literature regarding therapeutic medical treatment for long lasting infection is available it is however stated that adenoidectomy is the treatment of choice (Linder, Bates, Lee & Finkelstein, 2005).

Primary anatomical location for obstructive sleep apnea (OSA) is pharynx and nearby related structures along the respiratory tract with most likely involvement of retroglossal and retropalatal regions. Hypertrophic tonsils may result in OSA. Other factors include hypertrophic uvula, tongue, narrow oropharyngeal isthmus and mandibular retrognathia.

Therefore, it is important to carefully inspect all the related anatomy which is involved in the development of the disease process by an otorhinolaryngologist or sleep specialist (Yagi et al., 2009).

Regarding prevalence of tonsillitis in Pakistan a study has been conducted to provide facts and figures that depicts the magnitude of otorhinolaryngological illnesses in the local Pakistani population along with the appropriate surgical treatment to direct health policy makers for the execution of better development and planning. In this study the greatest frequency of patient who came to the hospital and admitted included pharyngeal issues with (31.04 %) prevalence, nasal disease (29.01 %), ear disease (16.71 %), oral and laryngeal disease (11.11 %). There were (54.54 %) patients with tonsillitis that was 234 out of 429 study participants (Rafi, Mehboob, Aftab, Saify & Rehman, 2017).

The most common surgical procedure conducted in the field of otorhinolaryngology is tonsillectomy. In the United States about 289,000 ambulatory surgeries done annually in pediatric population comprising of age less than 15 years (Mitchell et al., 2019). Typically both tonsils and adenoids may be excised at the same time. Tonsillectomy in combination with or without adenoidectomy is considered safe generally with low complication rates. Literature reported peak complication rate in the age group less than 2 years (Ng, Wong, Curotta, Trapani & Cheng, 2019).

Primary or secondary hemorrhage that occurs within and after 24 hours of surgery are the most serious complications. Sometimes these complications can be deadly. Other reported complications include pain, vomiting, dehydration and difficulty in swallowing (Messner, 2018). Post-surgical hemorrhage rate reported to vary from 0.5 to 16 % (Mattheeuws, Duhamel, Dhont, Dhooge & Van Hoecke, 2019).

1.1.1 HISTORICAL BACKGROUND

Cornelius Celsus in Rome explained the first extraction of tonsil in first century BC before Christ by using bare fingers, vinegar and milk were used to attain hemostasis, he also described difficulty in conduction of the procedure owing absence of proper anesthesia (Curtin, 1987). Later in 1543 Versalius gave the detailed description of tonsils along with its

blood supply (Feldmann, 1997). In 1761, the first precise account of pharyngeal regional anatomy was given by Duverney but in 19th century comprehensive gross and histologic studies were done by Wilhelm Von Waldeyer. As the time proceeded, in 1828 there was advancements in instruments used for tonsillectomy.

Physick introduced tonsillotome which was a modified form of uvulotome for the accomplishment of extraction of tonsils (Júnior, Hermann, dos Reis Américo, Stamm & Hirata, 2006). Young & Bennett (2004) stated in the history of tonsillectomy that Gregg Dillinger was the first person to introduce diathermy instead of usage of tonsillotome as this new method caused less bleeding and infection. According to Tarafder (2014) in 1920, Schmidt Sarmento performed the first tonsillectomy in Brazil.

At present the most common surgical procedure done in pediatric population in the world is tonsillectomy. To reduce pain, surgical complications and anxiety new methods like electro surgery and lasers were continuously being established. At the end of 19th century surgery of tonsils was initially done by general surgeons which later on became the dominion of oto-rhino-laryngologist because they have better techniques. In accordance with Young & Bennett (2004) useful steps in the progress of operation were later on established like mouth gags, snares, forceps, various kinds of scalpels and tongue depressors. Positioning of patients head which included leaning or suspended angle, was explained first by Killian in 1920.

These techniques were implemented after advances on anesthesia practices. Partial tonsillectomy was performed and suggested by many authors at the beginning of 20th century but total tonsillectomy became the most favored option from the third decade of this century (Tarafder, 2014).

Younis & Lazar (2002) concluded in their review that cold steel dissections with diathermy, monopolar or bipolar diathermy, USG guided operations, laser tonsillectomy, usage of harmonic scalpel and powered microdebrider are being used in present era out of which cold steel tonsillectomy is the safest and effective procedure. Evolution of techniques and equipments used for tonsillectomy- in order to meet the demands of modern practice-render it a defined and recommended operation. Currently this is a safe procedure and indicated commonly to treat airway obstruction, recurrent throat infections and childhood ear disease.

1.1.2 ANATOMICAL BACKGROUND

At the superior aspect of respiratory and gastrointestinal tract there is an incomplete ring formed by lymphoid tissue aggregations known as *Waldeyer's ring,* consisting of lingual, palatine, pharyngeal and tubal tonsils (Gleeson & Clarke 2008). Figures1, 2 and 3 show the anatomical position of tonsils along with its relations.

1.1.3 PALATINE TONSIL

Sinnatamby (2011) stated that these paired lymphoid tissues are located at the lateral wall of oropharynx on tonsillar fossa in between anterior and posterior pillars, which are formed by palatoglossus and palatopharyngeus muscle. The palatine tonsils have two surfaces medial and lateral.

1.1.3.1 MEDIAL SURFACE

The medial surface is covered by pharyngeal mucosa. The epithelium of the lymphoid tissue dips into the stroma forming tonsillar crypts, the largest of the crypt is located at the upper pole is the intratonsillar cleft or crypta magna.

1.1.3.2 LATERAL SURFACE

Lateral surface is covered by fibrous tissue capsule known as tonsillar hemi capsule which is a specialized portion of pharyngobasilar fascia. There is presence of loose areolar tissue between capsule and bed of tonsil. The tonsillar bed is made by inferior part of superior constrictor of pharynx and pharyngobasilar fascia. Other neurovascular structure related to this surface includes glossopharyngeal nerve and para tonsillar/external palatine vein. Superior pharyngeal constrictor separate this surface from two branches of facial artery that is ascending palatine and tonsillar artery. Posterolateral relation includes internal carotid artery approximately 2.5 cm from tonsil.

1.1.3.3 ARTERIAL SUPPLY

Tonsillar branch of facial artery is the main arterial supply. Lingual, ascending pharyngeal, ascending and greater palatine arteries also give contribution to it.

1.1.3.4 VENOUS DRAINAGE

Veins form a plexus around the capsule which drain into pharyngeal plexus and into internal jugular vein.

1.1.3.5 LYMPHATIC DRAINAGE

Deep cervical lymph nodes are involved in lymphatic drainage particularly jugulodiagastric (tonsillar) node.

1.1.3.6 NERVE SUPPLY

Tonsillar branch of glossopharyngeal nerve mainly and to a lesser extent by lesser palatine nerve, branch of maxillary nerve.

1.1.4 PHARYNGEAL TONSIL

Moore, Dalley & Agur (2013) explained that these are the lymphoid tissue aggregations in mucous membrane on the posterior wall of nasopharynx, which are known to be prominent in children. Increase in size of these nodules are known as adenoids

1.1.5 LINGUAL TONSIL

These are found at the back of tongue situated on the posterior one third. (Moore, Dalley & Agur, 2013)

1.1.6 TUBAL TONSIL

Sinnatamby (2011) describes that opening of the pharyngotympanic tube into the lateral wall of nasopharynx produces elevations of mucous membrane around the edges of the triangular opening. Aggregations of lymphoid tissues present beneath it is known as tubal tonsils.

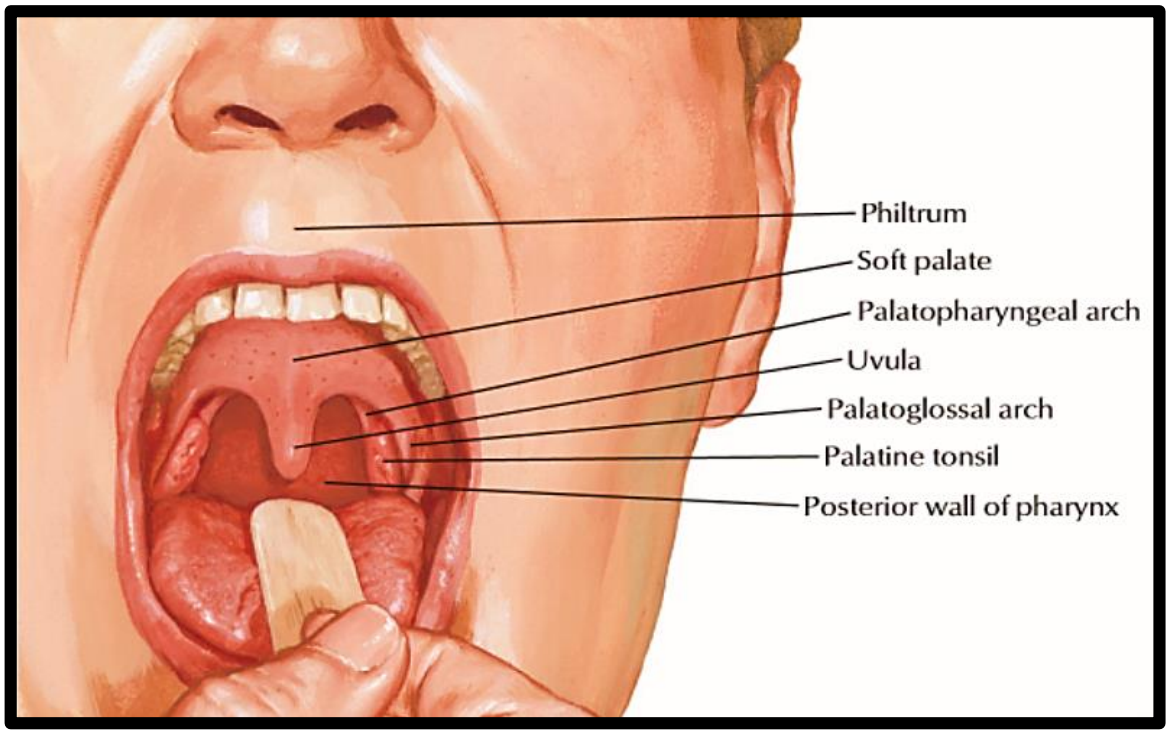


Figure 1: Location of palatine tonsil in oral cavity, extracted from Netter & Colacino (2011)

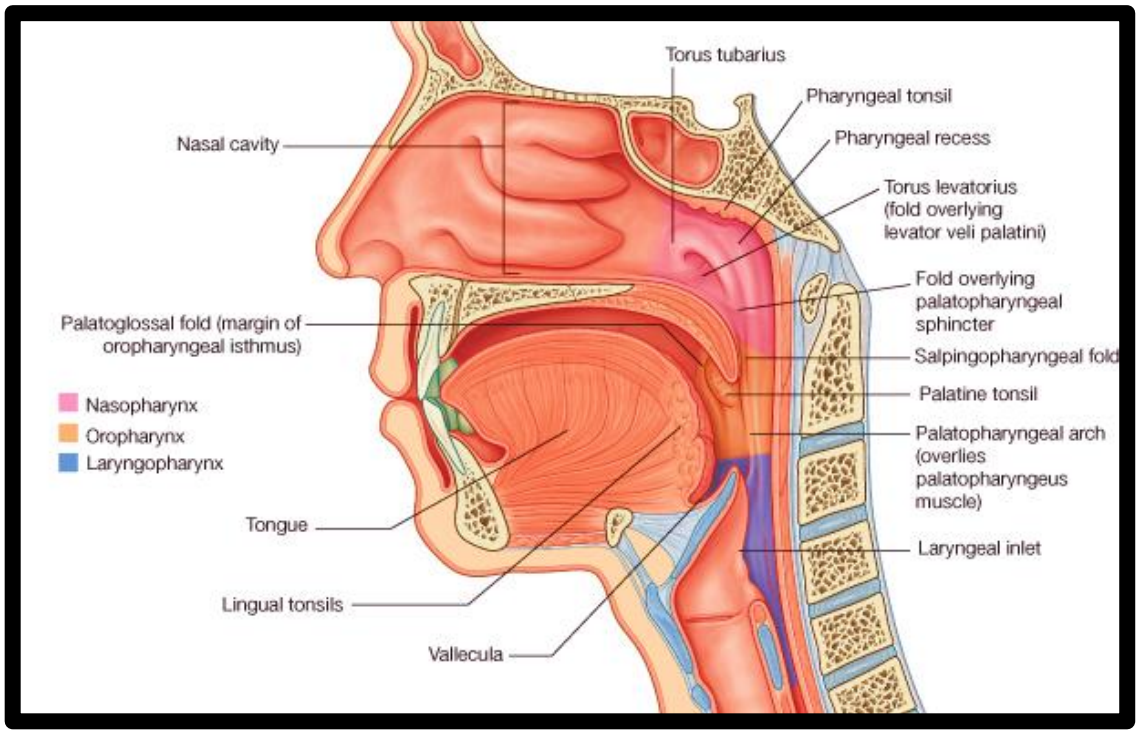


Figure 2: Mucosal features of the lateral view of pharynx (Standring, 2015)

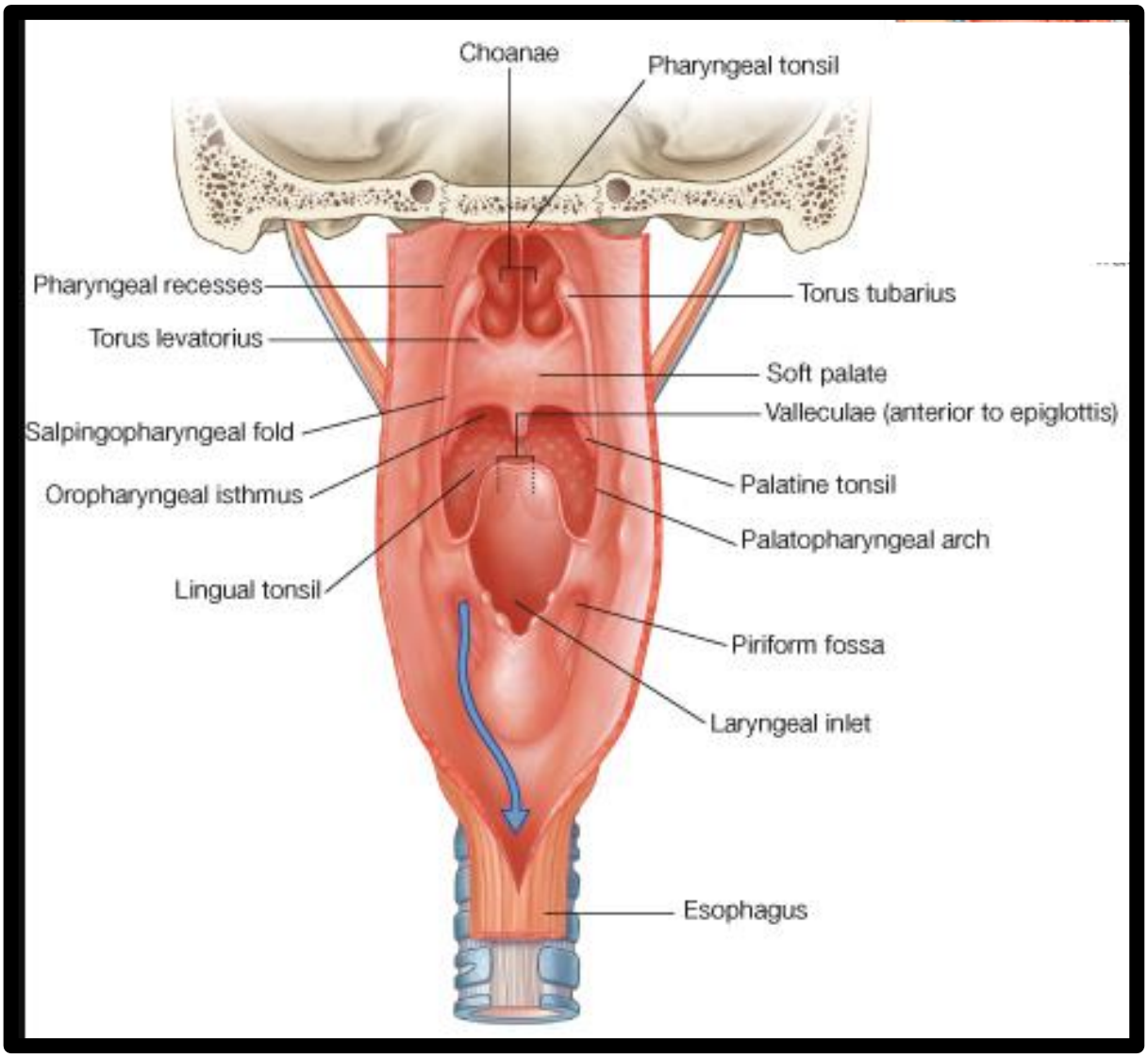


Figure 3: Posterior view of pharyngeal wall (Standring, 2015)

1.2 MICROSCOPIC ANATOMY

According to Ross and Pawlina (2018) palatine tonsil is enclosed in connective tissue capsule which separates it from adjacent structures. Palatine tonsil consists of stratified squamous non keratinized epithelium which is richly infiltrated with lymphocytes due to which it is difficult to identify the epithelium. It consists of diffuse lymphocytes and lymphoid nodules generally with germinal centers disposed under epithelium arranged like a band. Ten to twenty epithelial extensions into tonsillar parenchyma are seen forming tonsillar crypts that increase the surface area. These crypts contain dead epithelial cells, lymphocytes and bacteria as depicted in figure 4.

According to Junqueira (2013), pharyngeal tonsil is a single tonsil in posterior nasopharyngeal wall without crypts enclosed in a thinner capsule as compared to palatine tonsils. The epithelium comprises of ciliated pseudostratified columnar type thrown into folds along with lamina propria which contain diffuse lymphoid tissue and nodules. Lingual tonsil constitutes small, multiple lymphoid tissue aggregations at the back of tongue with a single deep crypt. The covering epithelium consist of stratified squamous cells without keratinization. Mucous glands' ducts open at their bases.

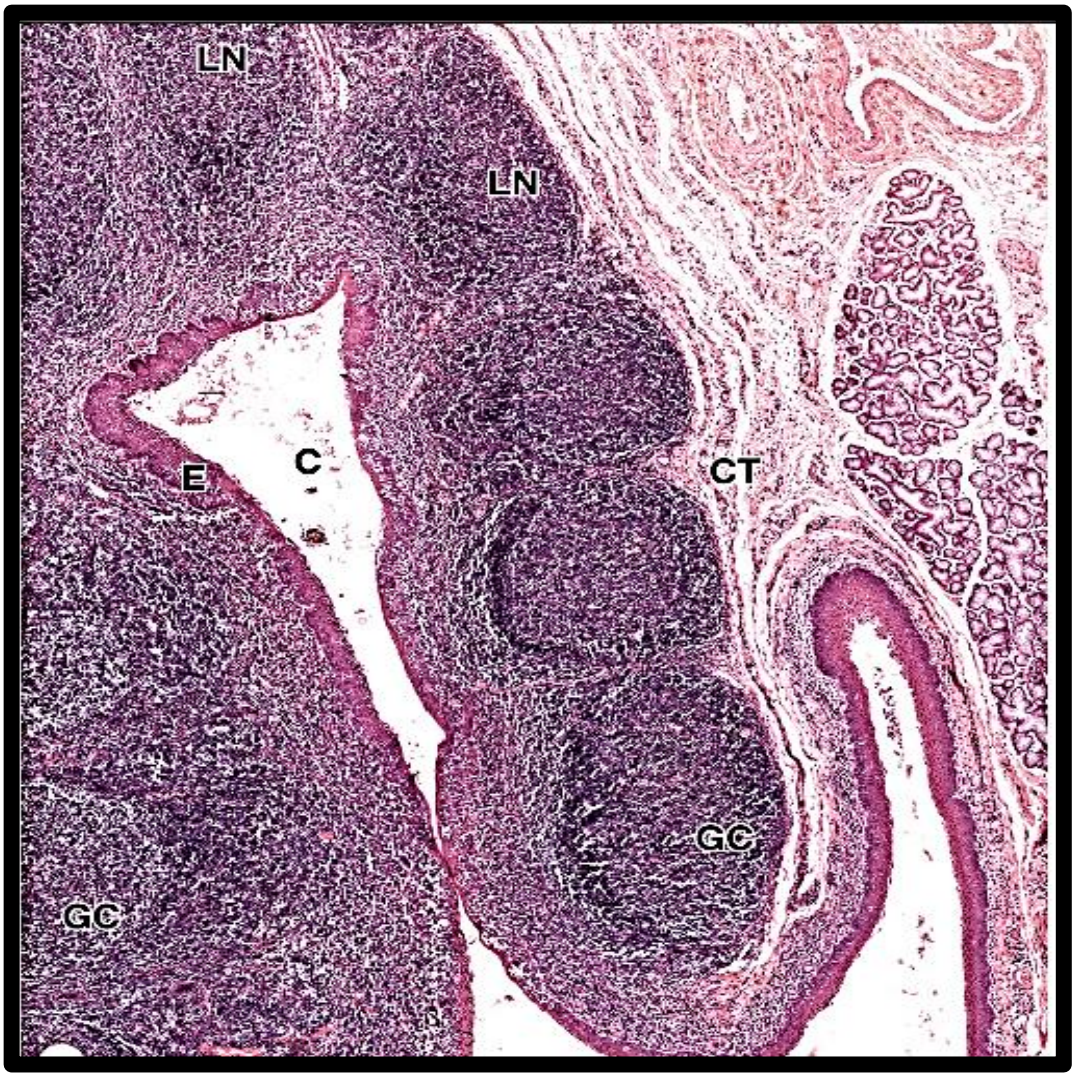


Figure 4: Micrograph of palatine tonsil showing several lymphoid nodules (LN), collectively covered by stratified squamous epithelium (E) on one side and a connective tissue capsule (CT) on the other. Some nodules show lighter staining germinal centers (GC). Infoldings of the mucosa in some tonsils form crypts (C). X140. H & E (Extracted from Junqueira, 2013)

1.3 DEVELOPMENTAL ANATOMY

1.3.1 PALATINE TONSIL

Moore, Persaud & Torchia (2018) describes the development of palatine tonsil which begins in early fourteenth week of fetal life from the endodermal lining of the ventral part of second pharyngeal pouch. Proliferation of these cells form solid endodermal buds that infiltrate into adjacent mesenchyme which are secondarily invaded by mesodermal tissue giving rise to stroma of the developing structure. Central cells of buds break down to form pit like depressions known as tonsillar crypts infiltrated by lymphoid tissue. Surface epithelium is formed by endoderm of the pouch. Figure 5 shows the development of tonsil

Sadler (2011) describes that at approximately sixteenth week of development mesenchyme surrounding the crypts differentiates into lymphoid tissue and later on organizes into lymphatic nodules of palatine tonsil. Portion of the pouch remains and leads to the formation of tonsillar fossa or sinus.

1.3.2 TUBAL AND PHARYNGEAL TONSIL

Moore et al., (2018) further explained that tubal tonsils develop from accumulation of lymphoid tissue adjacent to pharyngeal openings of pharyngotympanic tubes, Pharyngeal tonsil develop from accretion of lymphoid nodules in the wall of nasopharynx whereas lingual tonsil develop from addition of lymphoid nodules in the post one third of tongue.

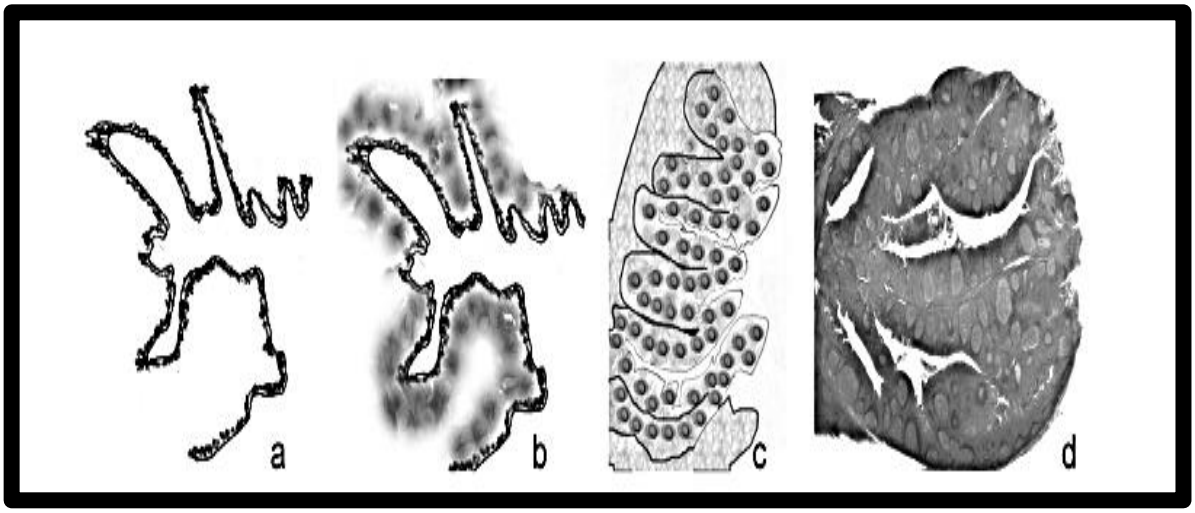


Figure 5: Embryological development of tonsil. (a) Illustration of epithelial evagination, (b) lymphoid cell infiltration of lamina propria, (c) development of primary germinal centers before birth and (d) the hyperplastic tonsil of childhood.

Extracted from Isaacson & Parikh, (2008)

1.4 ROLE OF TONSILS IN IMMUNE SYSTEM

Anatomical location of palatine tonsils is at the entrance of aero digestive tract where they act as a first line of protection against exposed pathogenic agents such as bacteria, viruses and type of ingested food such as cold and sour food. These lympho-epithelial organs are associated with integrated mucosal immune system of the pharynx. Immunologic activity of tonsils is highest in early years of childhood usually before 10 years of age but in extremes of ages that is up to 60 years the activity of Ig-positive B cells declines while there is no marked effect on activity of T- cells. Furthermore, in the age dependent involution of tonsil there is marked reduction in number of follicular dendritic cells (FDC) and interdigitating dendritic cells (IDC). Tonsillar parenchyma infiltered with M-cells, B cells, T lymphocytes and plasma cells. B-lymphocyte are mostly involved in immune process that is immunologic memory and antibody production. Memory B-cells are situated at germinal centers of secondary lymphoid tissue where these cells triggered by antigen exposure and undergoes proliferation enhancing the acquired immune response. Mature B-cells are found in the mantle zone which surrounds the germinal center. Mantle zone and germinal center comprise lymphoid follicle which is bounded by T-cells in the extra follicular area. Palatine tonsil do not have afferent lymphatic pathway through which antigens can be carried rather it has reticulated crypt epithelium that traps the pathogens and carried it to immunologically active lymphocyte as demonstrated in figure 6 (Nave, Gebert & Pabst, 2001).

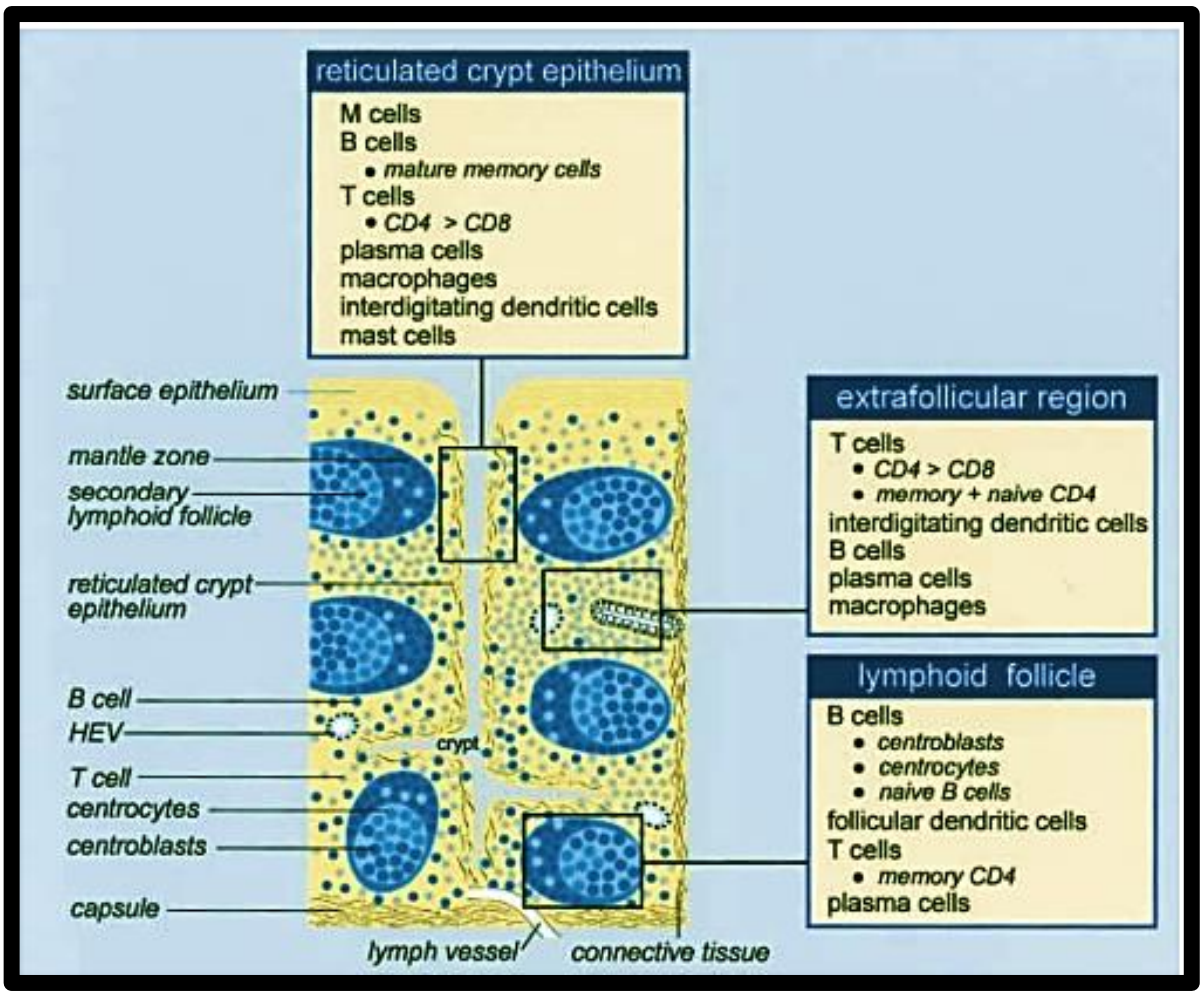


Figure 6: Illustration of palatine tonsil and cellular arrangement of different compartments, extracted from Nave, Gebert & Pabst (2001).

1.5 IMPORTANCE OF CLINICAL EXAMINATION

The features of physical examination are not definite or exclusive to the patient with acute or chronic disease of tonsil. Visualization of palatine tonsils in children is by means of a tongue depressor to gradually lower down the posterior aspect of tongue. In distinction with adult patients tonsils may be less noticeable secondary to involution but there is visualization of pillars. There is a grading system of tonsil that aids the clinicians to assess tonsil size with some degree of objectivity by quantifying the proportion of the tonsil occupying oropharyngeal isthmus commonly known as Brodsky grading scale which is the classical method and widely used. It is classified into 5 grades in which grade 0 indicates previous tonsillectomy; grade 1 indicates that the tonsils were hidden in the pillars; grade 2 indicates that the tonsils were beyond the anterior pillar and between 25 and 50% of the pharyngeal space; grade 3 indicates that the tonsils were beyond the pillars but not to the middle and occupied > 50% and up to 75% of the pharyngeal space; grade 4 indicates that the tonsils occupied > 75% of the pharyngeal space (Figure 7). The clinical presentation of patient with acute or chronic inflammation of tonsils differs in etiology, most commonly presenting with fever, difficult or painful swallowing, enlarge and erythematous tonsil. The highest manifestation of hypertrophic tonsil with obstructive symptomatology includes OSA. Therefore clinical examination should include identification of risk factors of OSA such as overweight or obese subjects, increased neck circumference, age above 40 years, nasal obstruction, and hypertrophic tongue, thorough upper respiratory examination along with Muller's maneuver. Collapse of soft tissues at base of tongue, above soft palate and pharyngeal obstruction can be visualized. Screening of the patients with hypertrophic tonsil should be done for OSA as this may go unobserved and undiagnosed (Lu, Zhang & Xiao, 2018). Most of the patients with OSA have higher tongue grading whereas effortless intubation is assessed in anesthesia using Mallampati scoring (MS). It is classified into four grades as shown in figure 8. Grade I indicates clear visibility of tonsils, fauces and soft palate, grade II involves visualization of uvula, tonsillar pillars and upper pole of tonsils, grade III comprises of partial visualization of soft palate whereas tonsils, pillars and uvular base are all not clearly visible and grade IV is denoted by visibility of hard palate only (Avincsal, Dinc, Ulusoy, Dalgic, Ozdemir & Develioglu, 2017).

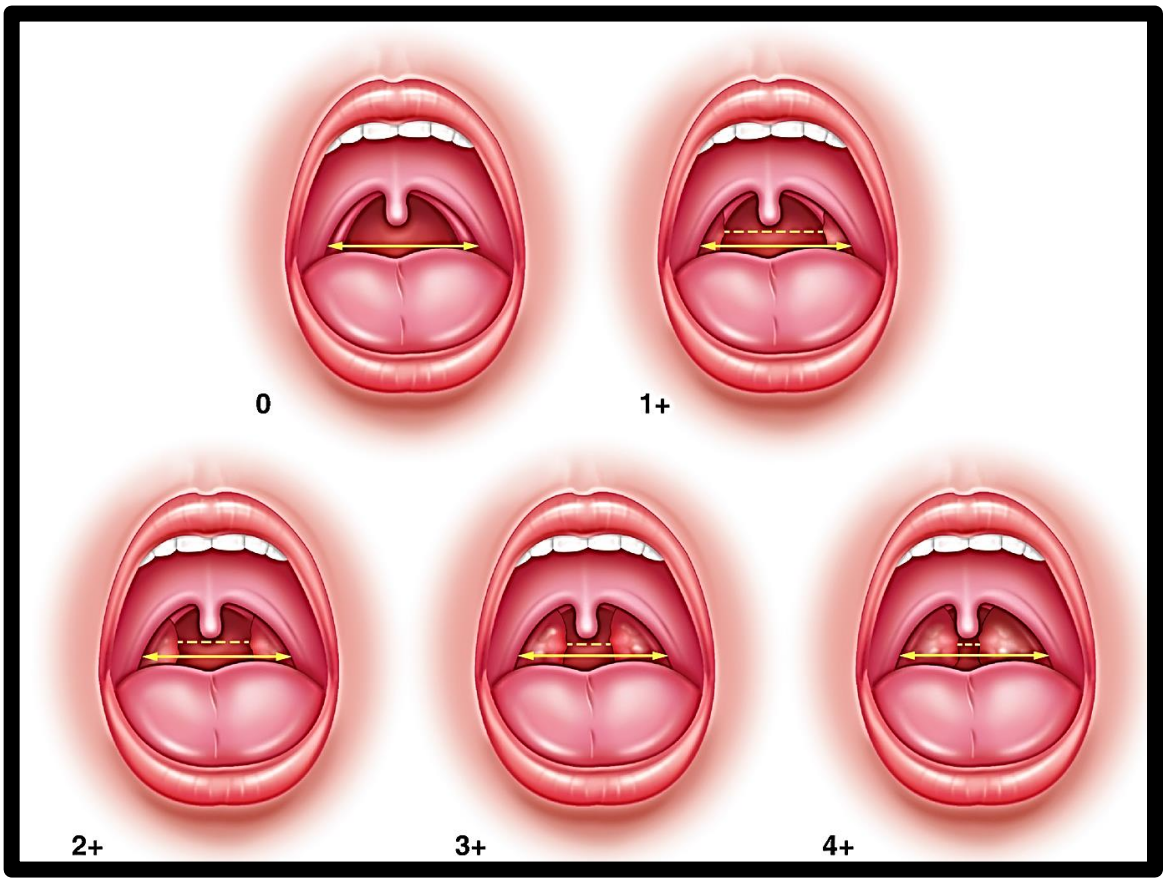


Figure 7: Brodsky tonsillar grading system. Percentage of occlusion of oropharynx. Extracted from Quimby & Salman, (2019).

- 0) Tonsils within tonsillar fossa, behind pillars or surgically removed
- 1+) 0-25%, grade I
- 2+) 25-50%, grade II
- 3+) 50-75%, grade III
- 4+) 75-100%, grade IV

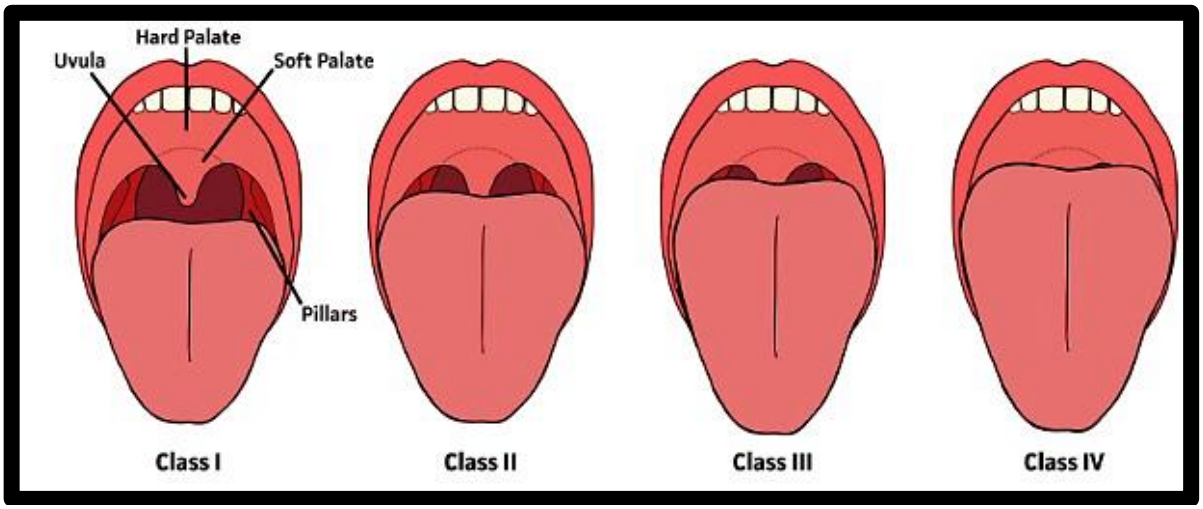


Figure 8: Mallampati scoring (MS) with increasing grades, extracted from Avincsal, Dinc, Ulusoy, Dalgic, Ozdemir & Develioglu (2017).

1.6 IMAGING TECHNIQUES

In addition to detailed history, physical examination, laboratory investigations and radiographs should be taken to assess craniofacial malformation or occlusion. USG should be done to evaluate actual tonsillar volume occupying and occluding aero digestive tract. Other imaging techniques involve magnetic resonance imaging and computed tomography (Mafee, Valvassori & Becker, 2005).

1.7 DISEASES ASSOCIATED WITH TONSILS

1.7.1 ACUTE TONSILLITIS

It is defined as an acute inflammation of tonsillar tissue. This condition most commonly involves school going children but patient of any age may be affected. In most of the cases it is viral in origin with superimposed bacterial infection. Group A Beta Hemolytic Streptococci (GAS) is the commonest infecting organism, others include Hemophilus influenza, Pneumococci, Moraxella catarrhalis, Staphylococci, Nocardia and Fusobacterium. Epstein Barr virus (EBV), influenza, enterovirus, rhinovirus, and adenovirus are the viral pathogens that frequently contribute to the inflammation of tonsillar tissue. Fever, malaise, dysphagia, odynophagia, tender cervical lymph nodes and hyperemic inflamed tonsil with hypertrophy of tonsillar tissue are the most common features when patient visited the outpatient department (OPD). Other clinical features include, earache, body ache, headache and weakness (Sidell & L Shapiro, 2012).

1.7.1.1 DIFFERENT CLINICAL FORMS OF ACUTE TONSILLITIS

On the basis of severity of the condition, morphological features of tonsils show different manifestations of acute tonsillitis, these forms are not every time distinguishable from each other and tends to merge. These include the following types

1.7.1.2 ACUTE CATARRHAL

It is also known as superficial tonsillitis as it includes the overlying mucous membrane and also involves pharyngitis.

1.7.1.3 ACUTE FOLLICULAR

The inflammatory pathogens extend into the tissue and occupied with infected pus and fibrin leads to distinguished spotted appearance as crypts opening are filled with purulent material

1.7.1.4 ACUTE PARENCHYMATOUS

It involves uniform enlargement and congestion of tissue. In this form there is extend of infection to the underlying lymphoid tissue and an increase of lymphoid follicles.

1.7.1.5 ACUTE MEMBRANOUS

This is the most severe form, there is formation of a false membranous covering of whitish yellow color on the tonsillar tissue which results from amalgamation of exudate from the crypts and can be effortlessly wiped off without bleeding.

1.7.1.6 TREATMENT

Suitable broad spectrum antibiotics should be given Penicillin or erythromycin is the drug of choice for streptococcal infection, patients allergic to Penicillin may be treated with clindamycin. Antipyretic and analgesic should be given for symptomatic treatment. General management includes rest, soft diet, proper hydration, and antiseptic gargles (Sidell & L Shapiro, 2012).

1.7.1.7 COMPLICATIONS OF ACUTE TONSILLITIS

Complications of acute condition are not very common due to practice of broad spectrum antibiotics but the condition may aggravate to chronic or recurrent form, peri-tonsillar abscess, retro or para-pharyngeal infection, otitis media, septicemia and many others (Sidell & L Shapiro, 2012).

1.7.2 CHRONIC TONSILLITIS

Involves repeated occurrence of inflamed tonsillar tissue for at least three months along with physical manifestation of inflammation of tonsil. Severity of the disease refers to five or more episodes per year of acute tonsillitis. Numerous micro-abscesses are present with in tonsillar tissue and are surrounded by fibrous tissue. Pathogenic agents present within these micro abscesses are not affected by antibiotics as fibrous tissue in this area is not vascular thereby

preventing antibiotics to act and eradicating the disease. When conditions become favorable these pathogens becomes activated and causes recurrence of the disease, several other factors are also associated with recurrence. These include sinusitis, bad oral hygiene, infected teeth and many other localized infections. Clinical features encompasses repeated attacks of sore throat, pain, difficulty in swallowing, fever, malaise and body ache (Bakar, McKimm, Haque, Majumder & Haque, 2018).

1.7.2.1 DIFFERENT CLINICAL FORMS OF CHRONIC TONSILLITIS

1.7.2.2 FOLLICULAR TONSILLITIS

Most commonly seen in adults, in this clinical form crypts of tonsils filled with infected mucopurulent discharge and its surface appears as if there were yellowish spots on it.

1.7.2.3 PARENCHYMATOUS TONSILLITIS

This clinical form is most commonly seen in children of ages between 4 to 15 years and involves proliferation of lymphoid tissue resulting in hypertrophy of the gland. Enlargement of tissue may interferes with swallowing, speech and respiration.

1.7.2.4 FIBROID TONSILLITIS

Due to recurrent tonsillitis there is presence of micro abscess and necrosis in the tonsillar tissue leading to fibrosis when healing occurs. Tonsil therefore appears small and shriveled.

1.7.2.5 TREATMENT

In case of acute attack involves appropriate cover of antibiotics along with general precautions and lifestyle modifications whereas for complicated conditions surgery is indicated.

1.8 INDICATION OF SURGERY

There are many national and international recommendations that exist for removal of tonsils. The most significant of them includes chronic or recurrent tonsillitis, hypertrophic tonsils that causes occlusive symptoms and difficulty in deglutination, respiration or speech. In quinsy in which there is accumulation of purulent material between capsule and lateral

pharyngeal wall, when there is a doubt of neoplasia in cases of unilaterally enlarged tonsil for histopathology, presence of tonsilolith, cysts, for an approach to the structures like glossopharyngeal nerve and styloid process present in tonsillar bed pharyngeal diphtheria to prevent carrier state or in the presence of secondary causes like rheumatic fever, endocarditis or glomerulonephritis (Udaipurwala, 2017).

There are various criteria mentioned in literature for removal of tonsils for recurrent tonsillitis which are summarized in table 1.

1.9 PERI-TONSILLAR ABSCESS OR QUINSY

It consists of accumulation of purulent material between capsule of tonsil and lateral wall of pharynx. It may occur after an acute attack of tonsillitis or may occur from the beginning. Infection may develop from crypta magna that penetrates through tonsillar capsule. At the beginning accumulation of pus is outside the capsule. Later when inflammation progresses it spreads and gathers between superior pharyngeal constrictors. Abscess lies mostly in the upper pole. In most of the cases it is unilateral and affects, young, adults and male gender but may occur at any age. Streptococcus pyrogens, Staphylococcus aureus or anaerobic pathogen are the most disease causing pathogens.

Usually there is sudden onset of symptoms followed by an acute occurrence of tonsillitis, high grade fever with rigors, severe throat pain, painful swallowing, dribbling of saliva as patient is unable to swallow, muffled voice, trismus, foetor oris and referred ear ache. On clinical examination congested swollen pillars, tonsils, and soft palate are usual manifestation along with edematous uvula pushed to opposite site as compared with affected site. Presence of tender, palpable cervical lymph nodes are also found in physical examination. Presence of generalized symptoms such as head ache, body ache and nausea may be seen.

1.9.1 TREATMENT

Initial treatment includes conservative medical treatment. Parenteral systemic broad spectrum antibiotics along with analgesics and anti-inflammatory drugs are recommended to be started immediately. Rest and antiseptic gargles are advised. In case of considerable

swelling with pointed protrusion of pus, incision and drainage is done, later on tonsillectomy is recommended.

Complications are infrequent with the advancement of broad spectrum antibiotics. Some of the complications that can occur includes parapharyngeal abscess, laryngeal edema, septicemia, pneumonia in case of aspiration, mediastinitis or jugular vein thrombosis (Gleeson & Clarke, 2008).

1.10 TONSILLECTOMY

The healthy palatine tonsils are the spots of uninterrupted formation of lymphoid cells and assumed as everlasting activation. Tonsillitis occurs when the pathological activity of pathogen exceeds the protective immunological activity of activated lymphocytes and immunoglobulin forming cells, therefore in recurrent forms excision of these tissues is the commonest therapeutic approach. It is still debatable whether its benefits exceeds its harm, as there is decrease in levels of serum immunoglobulin A levels by removal of large number of immunocompetent cells. Moreover, it has to be taken into notice that increase in size of these structures is not the only indication as they are normally larger in pediatric population as compared to adults and involute physiologically during adolescence.

The traditional yet the gold standard technique is the cold steel dissection which is safe and effective. Other methods include electrosurgical dissection like diathermy, radiofrequency ablation, microdebrider, laser, coblation, and harmonic scalpel (Gysin, 2013). Process of removal of tonsils is shown in figure 9.

Regarding effectiveness of tonsillectomy, Paradise et al., (1984) stated in a clinical trial that there is a decrease in sore throat infections after tonsillectomy in the initial two years of follow up after surgery. This finding concords with studies on pediatric patients by Goldstein et al., (2008). An “index of tonsillitis” was calculated by Kasenõmm, Piirsoo, Kull & Mikelsaar (2005) with a cut off value of 36 which includes number of episodes of tonsillitis per year and duration of infection indicates sclerotic level of tonsil. Score higher than this value is suggestive of tonsillectomy.

Table 1. Indication of tonsillectomy of patients with recurrent tonsillitis

Number of episodes of tonsillitis in a year (Udaipurwala, 2017)	7 episodes of tonsillitis in a year
	5 or more episodes of tonsillitis in each of 2 consecutive years
	3 episodes in a year for 3 consecutive year
Added criteria (Kim, Lee, Kim, Ha, Lee & Yeo 2012).	Oral temperature > 38.3° C, enlarge cervical lymph nodes size greater than 2 cm, tonsillar exudate or positive Group A β-hemolytic streptococcus
Other (Stelter, 2013)	OSA, Recurrent otitis media, blockage of nasal airway and oral passages, quinsy, diphtheria carrier state and tonsilolith

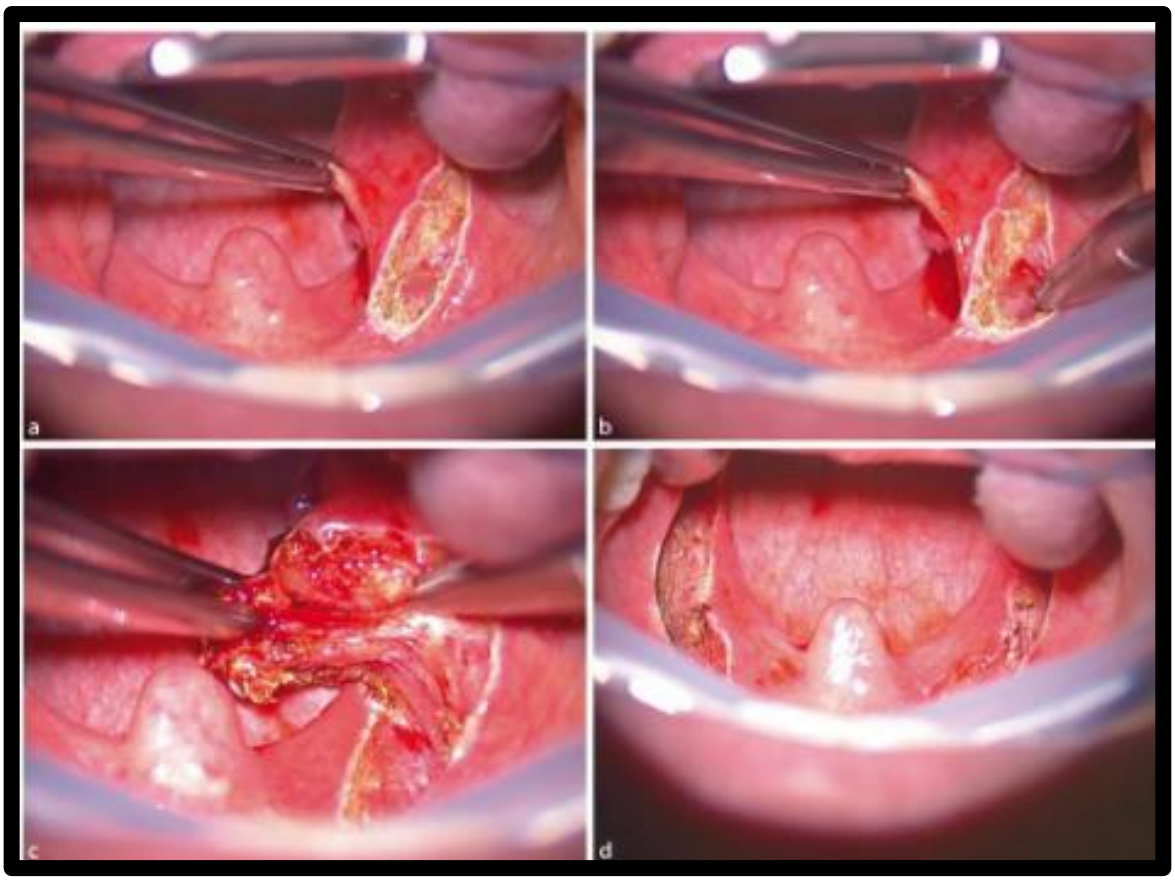


Figure 9: Removal of tonsils: (a) surgical incision, (b) exposure of accurate plane with scissors, (c) excision of tonsil towards the lower pole, (d) complete bilateral excision of tonsil.

Extracted from Anniko, Bernal-Sprekelsen, Bonkowsky, Bradley & Iurato, (2010).

1.10.1 COMPLICATIONS OF TONSILLECTOMY

Post-surgical hemorrhage is the most imperative complication of tonsillectomy that can be deadly. It is conservatively divided into three types which are described as follows (Udaipurwala, 2017)

1.10.2 PRIMARY HEMORRHAGE: Occurs when there is damage to Para tonsillar vein, happens on operation table and cured by ligation of the injured vessel.

1.10.3 REACTIONARY HEMORRHAGE: Involves bleeding within 24 hours, caused by displacement of ligature, elevated blood pressure and intense efforts like coughing, vomiting. It is managed by taking the patient to operation room and bleeder is ligated under general anesthesia and if there is minor bleeding it is treated conservatively by serial monitoring of patient.

1.10.4 SECONDARY HEMORRHAGE: Involves bleeding which is not profuse and occurs after 24 hours of surgery up to 14 days. It usually happens on 5^{th} day after surgery. Reason of bleeding comprises infected tonsillar bed, sloughing of tissue or opening of minute blood vessels in tonsillar fossa accompanied by fever. This condition is managed by giving the patient good cover of antibiotics, rest and observation of patient in hospital. In case of severe and profuse bleeding not settled by medical treatment then packing of tonsillar fossa is done under general anesthesia and pillars are tied together, packs are removed when the condition settles down.

There are various other reported complications of surgery such as damage to oral cavity, pharynx, palate, referred ear ache and post anesthesia problems. Some of them are summarized in table 2

Table 2. Complications of Tonsillectomy

Surgical Complications	Authors	Manifestations
Intraoperative	(Yamasaki & Bhattacharyya , 2019) (Gleeson & Clarke, 2008)	Anesthetic complication (cardiac arrest, atelectasis, cerebral hypoxia and others), intraoperative bleeding and burns
Immediate	(Johnson, Elluru, & Myer III 2002) (Udaipurwala, 2017) (Gleeson & Clarke, 2008)	Nausea, vomiting, dehydration, sore throat, otalgia, eustachian tube injury, fever, injury to oral cavity or pharynx. Others include post-operative pain and hemorrhage
Delayed	(Dhingra, 2014) (Gleeson & Clarke, 2008)	Velopharyngeal insufficiency, referred ear ache and postoperative hemorrhage
Long term	(Yamasaki & Bhattacharyya, 2019) Johnson, Elluru & Myer III, 2002) (Gleeson & Clarke, 2008)	Ear ache, nasopharyngeal stenosis, Eagle syndrome, regrowth of the lymphoid tissue, immunological changes and death

1.11 HYPERTROPHIC TONSIL ASSOCIATED WITH SLEEP DISORDER

According to literature it is estimated that about one third of our life is attributed to sleep which is an important aspect of an individual. It is further appraised that a healthy individual sleeps for about 7-8 hours, disturbed sleep affects one's life span (Gleeson & Clarke, 2008).

Increase in size of adenoids and tonsils as a response to immune system in children leads to airways occlusion and disturbed sleep. Symptoms caused by enlargement of lymphoid tissue can be mild or even not identified and realized. Symptoms can be severe enough that surgery is required. Sometimes there is extreme hypertrophy of tonsils that they reach in the middle in an approximate position known as "kissing tonsil" (Dhingra, 2014).

OSA is a disorder related with sleep during which there is an increase in tendency of airway to collapse either due to the tonicity of muscles of velum, oropharynx and hypopharynx or occlusion caused by hypertrophic tongue, tonsil or involvement of nasal passage. Symptoms of the disease include snoring, apnea, restlessness, somnolence, lack of attentiveness and poor performance at home and office (Lu et al., 2018). This in turn increases the risk of cardiovascular disease, hypertension, diabetes, infertility, reduced thinking and unexpected death. Increased neck circumference, weight gain, age above 40 years are the influencing factors for the disease (Naqvi, Shahab, Zia, Adil & Tariq, 2018).

This condition is associated with adverse health consequences that includes neurocognitive and functional impairment, thereby increases chances of motor vehicle crashes. Careful evaluation of a patient with these features like obesity, chronic smoking, usage of alcohol and sedatives, with narrow airway or increased tonsillar size, complaints of daytime sleepiness, loud snoring, breathing interruptions, poor work performance should be properly diagnosed. It has been assessed that about 80 % of the people remain undiagnosed of the state with 1.5-2 million cases ignored each year (Friedman & Jacobowitz, 2018).

Primary anatomical site for OSA is pharynx and nearby related structures along the respiratory tract with most likely involvement of retroglossal and retropalatal regions. Other factors include hypertrophic tonsils, uvula, tongue, narrow oropharyngeal isthmus and mandibular retrognathia. So, it is important to carefully inspect all the related anatomy which

is involved in the development of the disease process by an otorhinolaryngologist or sleep specialist (Yagi et al., 2009).

Clinical evaluation of OSA requires detailed history which leads to early diagnosis of the condition. A close family member such as a spouse can give more trustworthy information than the person himself because he was not aware of what's going on during sleep. Careful assessment of symptoms must be included in the history like snoring, mouth breathing increased daytime sleepiness, breathlessness, choking, unrefreshing sleep, bad temper, sunrise headaches, memory loss, impotence, menopause, hormone replacement therapy, use of alcohol, caffeine and tranquilizers (Gleeson & Clarke, 2008).

The Berlin questionnaire which was invented in 1996 is an easy and authentic tool for the estimation of sleep apnea risk in general population (Khazaie, Tahmasian & Herth, 2011). Its importance is also highlighted in metabolic syndrome by Gleeson & Clarke, (2008). This questionnaire has an equal importance for anesthesiologists and accepted as a screening tool to identify patients who are at higher risk of OSA and to establish the possible risk of developing postoperative respiratory complications in the Post Anesthesia Care Unit in China (Liu et al., 2018)

Physical examination should cover identification of risk factors such as weight gain with BMI $\geq$ 28 kg/m^2, neck circumference, detailed upper respiratory examination along with Muller's maneuver in which supple endoscope is passed through nasal cavity and patient is instructed to inspire with mouth and nose closed. In this way collapse of soft tissues at tongue base, above soft palate and pharyngeal obstruction can be visualized. Similarly, the disease may go unnoticed and underdiagnosed when patients visit any clinic or hospital, they are inquired about systemic disorders but not screened for OSA symptoms. Radiographs should be taken to assess craniofacial malformation or occlusion (Gleeson & Clarke, 2008).

Polysomnography is considered to be the "gold standard" for the diagnosis of OSA which includes the accounts for various observations like electroencephalogram, electrocardiography, electro-oculogram, electromyography, pulse oximetry, nasal and oral airflow, sleep posture, blood pressure and esophageal pressure. Another type is a split-night polysomnography which is conducted in two phases first usual polysomnography test is done followed by CPAP- Continuous positive airway pressures- titrations but these tests are very

expensive and require a lot of investigations of physiological processes and a night stay which in our setup is not easy (Gleeson & Clarke, 2008).

In evaluation of CPAP therapy, a cross-sectional survey reported out of 75 subjects 60 (80 %) continued CPAP therapy within one month of identification of the condition and 46 (61 %) used it for a long time more than one year. Adherence to the therapy was associated with improvement in daytime sleepiness following therapy. Poor compliance was associated with the use of antidepressants and sleep disturbance caused by CPAP therapy itself (Hussain, Irfan, Waheed, Alam, Mansoor & Islam 2014).

Changes in the way of life by reduction in weight, use of alcohol, smoking, sleep pattern and positional alterations during sleep such as lying supine that may cause occlusion of the airway. Intraoral devices such as MAD-Mandible advancement device and TRD-Tongue retaining device that alters the position of mandible and tongue to keep airway patent (Gleeson & Clarke, 2008).

1.12 HYPOTHESIS

1.12.1 NULL HYPOTHESIS

There is no relationship between ultra-sonographic tonsillar size and Brodsky tonsillar grading

1.12.2 ALTERNATE HYPOTHESIS

There is a relationship between ultra-sonographic tonsillar size and Brodsky tonsillar grading

1.13 OBJECTIVES OF THE STUDY

1. To determine the association between actual tonsil volume by USG and Brodsky tonsillar grading

2. To determine the association between the gender, age, weight and size of the tonsils

3. To substantiate the use of high frequency USG in diagnosis of tonsil enlargement

1.14 PROBLEM OF THE STUDY

The size of palatine tonsils differs with different age groups, and there is no standard measurement for tonsil size in Pakistani population which is important for evaluation of tonsil related pathologies.

OSA is a life-threatening disorder and has association with hypertrophic tonsils. It is either not diagnosed or not treated properly due to lack of awareness in our country. Its prevalence is increasing with growing years (Gleeson & Clarke, 2008). The above mentioned condition is associated with adverse health consequences, including neurocognitive and functional impairment and increases chances of motor vehicle crashes. Therefore, if a patient comes in an OPD who is an obese, smoker, uses alcohol, sedatives, having narrow airway or increased tonsillar size with complaints of daytime sleepiness, loud snoring, interrupted breathing, poor work performance should be necessarily diagnosed and evaluated properly. It has been assessed that about 80 % of the people remain undiagnosed of the state with 1.5-2 million cases ignored each year (Friedman & Jacobowitz, 2018).

For these reasons anatomical factors such as enlarged tonsils, hypertrophic tongue, with constricted or restricted air passage should be identified on physical examination and correlated with imaging techniques such as ultrasound measurements in order to avoid underestimation, overestimation or misclassification and to ensure correct diagnosis so as to refrain from serious harmful effects. There is a critical need for a study to provide with new endpoints for the disease prevention in Pakistan.

1.15 SIGNIFICANCE OF STUDY

This study will help the physicians to make early diagnosis by detecting morphological changes in pharynx. Primarily to prevent the patient with unnecessary surgery, secondarily if the surgery is done it may suppress the signs of sleep apnea as snoring, and this can lead to ongoing sleep apnea without being adequately recognized, diagnosed and treated. Present study will also enhance the ultrasonographic anatomy of tonsils and help the health care providers in estimation of tonsil volume occupying oropharyngeal isthmus. Dangers of untreated sleep apnea can include the development of high blood pressure, heart disease,

heart attacks, heart rhythm disturbances, stroke, chronic fatigue, memory and attention problems as well as accidents. In this way, this study will decrease the major burden of disease which in turn reduces morbidity and mortality. Furthermore, the current study also increases awareness regarding lifestyle changes and behavioral modification

1.16 OPERATIONAL DEFINITIONS

1.16.1 Sleep Apnea:

"Cessation of breathing that lasts for 10 seconds or more during 7 hours of sleep"

Dhingra, (2014) ; Udaipurwala, (2017).

1.16.2 Body Mass Index: "It is calculated by dividing body weight in kilograms by height in meters square. Normal BMI, 18.5-24.9; overweight, 25-29.9; and obesity, 30-34.9"

Dhingra, (2014) ; Udaipurwala, (2017).

1.16.3 Collar size:

"Neck circumference at the level of the cricothyroid membrane is measured. Collar size should not exceed 42 cm in males and 37.5cm in females"

Dhingra, (2014) ; Udaipurwala, (2017).

1.16.4 Epworth Sleepiness Scale (ESS):

"The commonest subjective questionnaire used is the Epworth Sleepiness Scale, named after the Epworth hospital, Victoria, Australia. A score above 10 (out of 24) may indicate excessive daytime sleepiness but lacks sensitivity and specificity" Gleeson & Clarke, (2008).

1.16.5 Brodsky grading scale:

“Classified into 5 grades as follows: grade 0 indicated the previous tonsillectomy; grade I indicated that the tonsils were hidden in the pillars; grade II indicated that the tonsils were beyond the anterior pillar and between 25 and 50% of the pharyngeal space; grade III indicated that the tonsils were beyond the pillars but not to the middle and occupied > 50% and up to 75% of the pharyngeal space; grade IV indicated that the tonsils occupied > 75% of the pharyngeal space” Lu, Zhang & Xiao. (2018).

1.16.7 Modified Mallampati grade:

Classified into 4 grades as follows

“Grade I: Tonsils, pillars, and soft palate are clearly visible; Grade II: Uvula, pillars, and upper pole are visible; Grade III: Soft palate is partly visible; while the tonsils, pillars, and base of uvula are all invisible; Grade IV: Hard palate only is visible" Yagi et al., (2009).

CHAPTER 2

LITERATURE REVIEW

Every existing individual is continuously endangered by variable amounts of precarious entities like bacteria and viruses that enter the body during eating and breathing. In order to protect the human body with this potential threat lymphoid tissue aggregation is present in the oropharynx which is the first line of defense forming Waldeyer's ring and are also known as mucosa associated lymphoid tissue (MALT) (Gleeson & Clarke 2008).

The variation in size of palatine tonsil depends upon age, distinctiveness of an individual and disease status. There is a prompt increase in size of tonsils at about fifth or sixth year of age attaining maximum size at adolescence. At this stage the tonsils measure up to 20 to 25 mm in perpendicular diameter and 10 to 15 mm transversely (Susan, Harold, Jermiah, David, & Andrew, 2005).

A Turkish study conducted by Songu, Adibelli, Tuncyurek & Adibelli, (2010) in which researchers explored normal values of structures related to upper airway and their relation with age by magnetic resonance imaging. Study participants included 292 pediatric population without sleep disorders or any related symptoms that could be linked with breathing difficulties. The mean width and size of palatine tonsils increased up till 4 to 5 years of age then its size remained at plateau phase until 11 years of age, and stabilized thereafter. In a study mean tonsils volume in healthy children using trans-cervical USG was found to be approximately 1.8 to 2 ml^3 (Ozturk, 2017).

One of the pioneer ultrasonographic study compares ultrasonographic volume of palatine tonsils with true volume which was calculated postoperatively by water displacement method reported that they correlate with each other (Asimakopoulos, Pennell, Mamais, Veitch, Stafrace & Engelhardt, 2017).

2.1 GLOBAL HEALTH ISSUE

OSA is a serious life-threatening disorder and has relation with enlarged tonsils. It is evolving as a "global health epidemic" (Seeger-Zybok, Klingelhöfer, & Groneberg, 2018). It is either not diagnosed or treated properly due to lack of awareness and ignorance of the condition not being recognized and identified. Further it is associated with adverse health consequences such as neurocognitive disorders, functional impairment and increased chances of motor vehicle crashes. Prevalence of the disease is increasing with growing years (Gleeson & Clarke, 2008). It is 3-7 % prevalent in Pakistani population (Naqvi et al., 2018) occurring in both genders and includes all ages with a predominant male predisposition (Pasha & Khan 2003).

Tonsillitis is known to be a public health concern owing to its rate, occurrence and socio economic influence. Regarding its global prevalence after rhinosinusitis and otitis it is known to be the third most common infections in the field of Ear, Nose and Throat (ENT). In United States tonsillitis accounts for 40 million cases per year or more than 5 % medical consultations in America, about 1.8 % of tonsillitis accounts in Mali, 9 million new cases are identified each year in France and 4 million in Spain with 15% medical consultations (Haidara et al., 2019).

2.2 NATIONAL HEALTH ISSUE

Prevalence of ENT diseases in Pakistani population accounts for 31.04 % for pharyngeal infections, 29.01 % for nasal disease, 16.71 % for ear pathologies, and 11.11 % for oral and laryngeal diseases out of which 54.54 % were with tonsillitis (Rafi et al., 2017).

2.3 PREDICTIVE ESTIMATION OF TONSIL SIZE

According to Gleeson & Clarke (2008) the activity and size of tonsil is greater during early childhood due to greater immunologic activity but later becomes smaller during advancing years. Its physical appearance gives false assessment of its extent. Some of the tonsils lie on the surface of shallower tonsillar fossa, others buried in the tonsillar fossa give false estimation of its size.

Brodsky and Friedman's tonsillar classifications are standard classifications. Brodsky classification is used worldwide. It is easy to perform and costs less but has limitations like

subjectivity and objectivity. Subjective factors include increase neck tissue mass, embedded tonsils within tonsillar fossa which influence clinical classification leading to underestimation or overestimation of lymphoid organs resulting in more errors like overlooked surgical chances or overtreatment (Lu, Zhang & Xiao 2018).

Evaluation of tonsillar volume is significant in clinical routine, which is a foremost feature related to OSA patient as removal of enlarging tonsils increases the narrowed oropharyngeal isthmus. Grading of tonsils is considered as a predictive factor for the successful surgical result (Jara & Weaver, 2018). Correlational analysis of tonsillar grading and tonsillar volume in a prospective cohort done in adults showed the mean post-operative volume of tonsillar tissue for grade I, II, III and IV was 2.58 ± 1.15, 4.33 ± 1.99, 6.58 ± 2.69 and 9.33 ± 1.15ml, respectively and found a significant relationship between them (Lu, Zhang & Xiao, 2018).

It was documented in 2015 that size of tonsil does not influence the severity of OSA. The study was conducted on 70 children of ages between 1 to 18 years undergoing adeno-tonsillectomy, polysomnography was done before and after surgery. Forty percent subjects (28/70) who were categorized as grade 3 + and 4 +, their symptoms resolved completely after surgery. Improvement in Apnea Hypopnea Index also noted from the median of 11.8 ± 21.7 to 2.0 ± 6.1 apneic events/hour (Tang, Benke, Cohen, & Ishman, 2015). Another prospective study which included adult primary snorers or OSA subjects determined a significant association between tonsillar volume with age (p-value 0.001), BMI (p-value 0.004), Friedman grade (p-value 0.028), Mallampati grade (p-value 0.001) and with Apnea Hypopnea Index (p-value 0.006), (Cahali, Soares, Dantas & Formigoni, 2011).

Jara & Weaver, (2018) revealed the coherent correspondence between subjective and objective tonsillar dimensions and added that Brodsky grading was more effectively linked with OSA severity than palatine tonsillar volume. Jones, Burnside, McPartland, Markey, Fallon & De (2018) in a review article published in the International Journal of Pediatric Otorhinolaryngology supported the significance of tonsillar grading in the asymmetric tonsil. Lymphoma is the third most common malignancy in the juvenile population with 12 % out of a total childhood cancer. Occurrence of 130 per million children in the United Kingdom. In 90 % of cases, tonsil lymphoma was Non-Hodgkin and can be diagnosed early. Removal of asymmetric tonsils is done for the investigative purpose for the exclusion of malignancy

with associated post-operative hemorrhage in 3.5 % children. The author also added to the literature that isolated tonsils without any apparent transformation for over 6 weeks may not be removed. Active observation of additional symptoms is an appropriate treatment strategy in children with visibly unequal tonsil.

2.3.1 OTHER PREDICTIVE MEASURES FOR HYPERTROPHIC TONSILS

Apart from history and examination, polysomnography which is the most accurate test requires overnight sick bay stay is not patient friendly and cost-effective. Therefore, in order to screen a large population, Epworth and Berlin's questionnaire was developed. Unlike tonsillar size high Mallampati grade is also associated with OSA and can be used as an influencing factor or screening tool as reported by Naqvi et al., (2018).

In medical and research practice, the evaluation of sleepiness is significant even though there is no specific criteria that describe sleepiness. In order to asses sleepiness there are various different tools which involves objective measures such as psychomotor vigilance test, multiple sleep latency test, wakefulness maintenance test and certain authenticated questionnaires. The ESS is a genuine scoring scale commonly used in clinical practice and research with broad applicability. This scoring scale ask the subject to grade their likelihood of sleepiness in 8 different questions, score is higher in subjects with airway pathologies such as in OSA patients and narcolepsy and scores are low in subjects with insomnia. In patients with sleep disorders there is a great amount of test-retest inconsistency that likely impact clinical management. (Walker, Sunderram, Zhang, Lu & Scharf, 2020).

A Turkish cross sectional study evaluated the predictive strength of known subjective screening questionnaires in order to detect the high risk patients for OSA in accordance with age, gender and comorbidities, the study included STOP-Bang questionnaire, Berlin questionnaire and Epworth Sleepiness Scale. For identifying high risk patients of OSA, STOP-Bang questionnaire had the greatest sensitivity and was better and higher to other two inquiry form in the different age groups, sex and comorbidities. Taking in view the close relationship of OSA with comorbidities, it is difficult to screen all those patients visiting OPD of medicine, cardiac or chest disease units (Arslan, Hoşgör & Orman, 2019).

OSA offers a means of poorly happened prerequisites, from screening to identification to cure, there are exciting chances for the potential inventor, and the use of smartphones is also another tool to screen or detect the disease, snore lab application helps to determine snoring intensity, quality and pattern that can be reassessed, later on, other advancements include sleep tracking device, like a wrist watch which is constructed on Actigraphy, a non-invasive method of calculating one's rest/activity cycles, which quantify gross motor activity (Friedman & Jacobowitz, 2018).

2.4 PHYSICAL METHODS FOR DETERMINATION OF TONSIL SIZE

Various methods developed for estimation of actual volume includes measurements of various parameters on excised specimens, these include Archimedes' Principle according to which water displaced by excised specimen measured as real volume. Ellipsoid formula in which total tonsil volume is calculated as product of length, width and depth of the specimen, multiplied by 0.523, measured by sliding calipers and ruler. Cavalieri method involves physical sectioning of surgical specimen of equal thickness then addition of volumes of each section by incorporating values obtained in a certain formula for total volume of a specimen (Sağıroğlu et al., 2017).

Subjective grading of tonsils may be affected by hypertrophic uvula, uvula-palatal arch variations and raised tongue position which in turn leads to imprecise correlation between subjective and objective palatine tonsil size. Size of palatine tonsils can be misjudged by subjective assessments due to entrenched tonsils or excessive nearby pharyngeal tissue. Consequently it is still pondered that subjective assessment done through clinical examination depicts the actual tonsil volume or size. Whereas CT scans and MRI have certain restrictions regarding pre-surgical evaluation of tonsils. Success of tonsillectomy surgery can be predicted by size of the tonsil. Hence assessment of precise size of palatine tonsil is an essential factor in patient's successful operation. A retrospective study which included 51 adult patients with mean age of 42.1 years (age range from 27 to 62 years) evaluated subjective and objective tonsil size - in study participants with sleep disordered breathing-determined their correlation and effect of size of tonsils on disease process. Subjective evaluation of tonsils was done by Friedman's classification whereas objective assessment includes usage of rulers and calipers for measurements of length, width and thickness of the

resected specimen and volume assessment of resected tonsils was done by water displacement method. According to the authors of study subjective grading of tonsils might reveal actual tonsil measurements whereas actual measurements were more expressive in mediating the seriousness of the disease like obstructive sleep apnea-hypopnea syndrome. Further they concluded that size of tonsils could not be predicted by BMI, shape of the body or anatomy of the upper airway. Therefore dynamic and four dimensional methodologies should be used for real or actual tonsillar size in OSA patients (Lai et al., 2014)

Another prospective study conducted on 277 children and 63 adults, compared subjective and objective size of palatine tonsils, subjective grading involved pre surgical evaluation of tonsils via Friedman's classification whereas objective method of estimation of tonsil size involved usage of rulers and calipers and measurements of length, width, height and volume of resected samples. The authors of the study concluded that in both children and adult actual volume of palatine tonsil correlates well with subjective size of the tonsil. However there discordance was observed in grade 2 and 3. Therefore limiting the significance of subjective evaluation of tonsil size in pediatric population whereas in adults preoperative assessment through subjective scoring predicts the real tonsil size. (Wang, Chung, Jang, & Lee, 2009).

A Turkish prospective clinical study used Archimedes principle for volume estimation of tonsils. In this study researches correlated subjective tonsil size estimated through grading with objective volume of palatine tonsil, BMI, body surface area, age and gender. The study was conducted on pediatric age group of 3 to 15 years with 292 study participants. They found statistically significant correlation between subjective and objective tonsil size with p-value 0.008 and BMI with p-value 0.013. There was also significant association of objective volume with age and body surface area with significant p- value (Yasan, Aynali, Erdoğan, & Yariktaş, 2011).

2.5 IMAGING TECHNIQUES FOR ESTIMATION OF TONSIL SIZE

In pediatric evaluation of tonsils, imaging is significant as physical examination is reported to be difficult in children. Polysomnography which is highly expensive and not readily available, is used as an objective measure. Therefore, it is used for the patients whose

diagnosis is doubtful, ambiguous history and for pre surgical documentation (Brodsky, Adler & Stanievich, 1989).

2.5.1 LATERAL RADIOGRAPHIC IMAGING

Predictive measures for estimation of tonsil size includes radiographic, ultrasonographic, computed tomography and magnetic resonant imaging. It is eminent that the lateral view of skull radiograph is valuable for the assessment of adenoid hypertrophy, nasopharyngeal narrowing and hypertrophic tonsil can also be seen as a shadow in the skull lateral view. Further radiographs can be easily prescribed for pediatric patients in an out-patient department with immediate results but tonsil size cannot be evaluated accurately. Lateral image is a two-dimensional picture. It does not give the transverse extension of the tonsillar tissue. Additionally there is very less literature regarding physiologic progression of tonsil that promote rise in impreciseness of estimation of tonsil size, either it is hypertrophic or not (Diamond, 1980).

2.5.2 CT-SCAN IMAGING

Computed tomography is most commonly used modality for evaluation of tonsillar pathology that can differentiate fluid density along with marginal enhancements of inflamed tonsil. It is highly sensitive for peri-tonsillar abscess and specific for non-drainable and phlegmonous swellings. On the other hand this imaging technique is challenging as well as it is difficult to distinguish anterior and posterior fauces as they have same attenuation coefficients (Mafee, Valvassori & Becker, 2005).

2.5.3 MR-IMAGING

Regarding magnetic resonant imaging tonsillar tissue is troublesome to distinguish from muscle on T1 weighted images because both are almost isointense. Whereas on T 2 weighted images tonsil possess greater intensity of signal as compared to nearby muscles because of the composition of lymphoid tissue and submucous glands with in the tonsillar tissue have elongated relaxation time as compared to neighboring muscles (Mafee, Valvassori & Becker, 2005).

2.5.4 ULTRASOUND IMAGING

USG is used less frequently for assessment of peritonsillar abscess due to patient body stature which includes age of the patient, technical skills and a comparatively restricted evaluation of nearby structures. This is the safest procedure as it involves use of non-ionizing radiations as compare to other imaging techniques. Imaging performed either using high frequency trans-cervical or intra oral probe with help of tongue blade as this locus allows easy aspiration of abscess. Consistency of an abscess on USG is usually hypoechoic or anechoic focus with relatively hyperechoic margin and augmented vascularity on color Doppler (Kim, Park & Chung, 2019).

Trans-cervical USG imaging technique is considered generally safe as it is non-invasive, valuable in detection of head and neck masses and devoid of harmful radiations. In recent times, this imaging technique has been gaining significant value because of its ability to visualize the oral cavity and pharynx with meticulousness. Effective and successful use requires a thorough knowledge of airway anatomy and USG experience. This modality is an adjunct to the assessment of upper airway is an alternative and complementary imaging method to magnetic resonance imaging and computed tomography which have certain limitations. Pre-surgical evaluation of tonsil anatomy with USG is thought to be valuable for the estimated response to tonsillectomy and perioperative distresses (Faraji et al., 2018).

For the ultrasonographic evaluation of palatine tonsil there are two widely used techniques; one include intraoral approach whereas other is external or transcutaneous approach. Intraoral probe covered by gloves or some other material is inserted into the oral cavity. Though special intraoral probes existed for this purpose that visualizes deeper areas of oropharynx. Visualization of tonsillar bed can be done by moving the probe slightly in transverse plane above the hyoid. Tonsillar tissue appears hypoechoic with well-defined margins along with many echogenic reflection owing to minor air inclusions as shown in figure 10. Variation in its size is influenced by age and other factors which possess pronounced inter individual variability. Palatine tonsils affected by acute or chronic inflammation visualized as enlarged tissue with hypoechoic alterations and sometimes less pronounced margins (Figure 11). This modality can easily visualize space occupying lesion touching tonsillar bed. Abscess can be easily distinguished on USG as a central anechoic area

with secluded internal echoes signifying presence of cellular debris and distal acoustic augmentation. Trans-cervical USG is an important diagnostic tool as it can be used in patients with trismus like conditions whereas intraoral technique is not well endured by pediatric patients because of the difficult inspection, trismus and probe size. (Heinrich, Johannes & Alessandro 2013).

2.5.5 HIGH FREQUENCY TRANS-CERVICAL ULTRASOUND OF PALATINE TONSIL

Identification of oral structures such as visualization of tonsils through USG requires usage of high frequency probes as these are superficial and needs use of curvilinear probe of frequencies between 2 to 9 megahertz having larger field of view and usage of a planar linear probe with frequency range from 4 to 15 megahertz which provides good resolution and detail image of superficial tissues. Usage of probes also depends upon age of subject, as well as usage of curvilinear probes preferred in young adults and linear probes in children. Therefore through such sonographic window it is frequent to observe all the anatomical entities starting from chin moving distally to the hyoid bone. Tonsils visualize as hypoechoic along with presence of air with in the crevices of the tissue. Mirror images will be demonstrated when contralateral side of upper neck will be scanned (Figure 12), (Stafrace, Engelhardt, Teoh & Kristensen, 2016)

Ultrasonography (USG) is frequently used to evaluate cranio-cervical growths or masses. However, for visualization of tonsils, the usage of this modality is scant. USG was used to distinguish peritonsillar cellulitis from tonsillar abscess in adults. Its use has shown an outstanding sensitivity and specificity in order to differentiate between tonsillar infections (Secko & Sivitz, 2015). Therefore it is evident from literature that USG can be an acceptable imaging technique for the evaluation of tonsillar shape, size, appearance, perfusion, pathology and as well as severity of obstructive sleep apnea by identifying pathological changes of the anatomical structures that basically cause it (Ozturk & Kilinc, 2017).

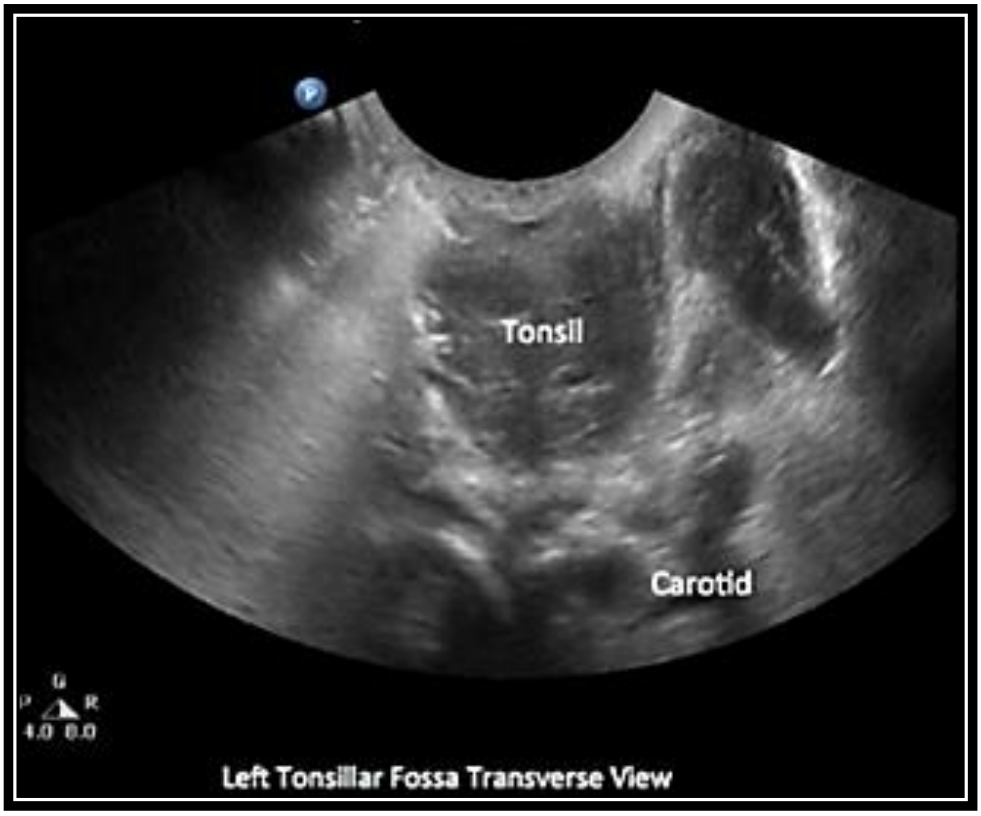


Figure 10: Intraoral method of visualization of palatine tonsil (Heinrich, Johannes & Alessandro, 2013)

Figure 11:Split screen (submandibular region), acute tonsillitis: The two tonsils (T) are enlarged with blur margins without clear distinction of surrounding tissue, other structures mylohyoid (MM), submandibular gland (GSM) and tongue (ZU) are visible. Radiograph extracted from Heinrich, Johannes & Alessandro (2013).

In adults, for over 30-years high frequency USG has been used for the detection of peritonsillar infections. However, in the past few years use of this modality is highlighted to observe the tonsils in pediatric population (Huang, Vintzileos, Gordish-Dressman, Bandarkar & Reilly, 2017). In the pediatric domain, Bandarkar, Adeyiga, Fordham, Preciado & Reilly, (2016) reported first time use of tonsillar USG of various tonsillar pathologies along with comprehensive photographic accounts. Authors of the study used this novel technique to differentiate tonsillitis, tonsillar abscess, peritonsillar cellulitis and infections. This technique determines palatine tonsils effectively and accurately as well as it is very practicable and non-invasive choice. In spite of presenting great assertion for identifying different tonsillar pathologies, authors of this research reported that there are no studies in the literature that confirms precision of this imaging technique in assessing volume of tonsil in different scopes.

An USG study, which is the first of its kind, was performed on 26 children in which they has compared preoperative trans-cervical tonsillar USG measurements with excised tonsils and volume assessment by water displacement method. The mean ± SD ultra-sonographic size was 3.6 ml (± 2.5 ml) and actual tonsillar size was 3.9 ml (± 2.1ml), p-value 0.24 which is not significant but have correlation with real tonsillar size (r = 0.89), these findings could help in further perioperative risk stratification of pediatric patients planned for surgery who could or not undergo OSA syndrome. However, both measurement methods showed no distinction but compliance of sonographic measurements was (Asimakopoulos et al., 2017).

Kay-Rivest, Saint-Martin & Daniel (2019) are the pioneers to affirm size of tonsil in three scopes can be exactly distinguished with USG and relates with ex vivo specimens. In their prospective analysis they compared tonsillar USG dimensions to actual pathology in 75 consecutive children going through surgery for various reasons. In general, USG mildly underestimated tonsillar size. The right and left tonsils which were assessed exhibited dissimilarities between measured volumes of pathology specimen and USG volume of - 0.075 cm^3 for right volume and - 0.221 cm^3 for left volume at confidence interval of 95 %. They have concluded that high frequency USG is an effective technique to evaluate acute and chronic tonsillar disease in pediatric population.

In a study pre-surgical evaluation of subjective and actual volume after tonsillectomy were compared in which investigators of the study established that tonsil sizes were higher in the

subjects who were overweight and suffering from Obstructive sleep apnea syndrome (Wang et al., 2010).

Obesity is one of the most important influencing feature for OSA. Progress of this condition likely involves increase in appetite hormones triggered by disturbed sleep whereas losing weight might help the mild condition but not the severe one (Hamilton & Joosten, 2017).

A study which involved 277 pediatric cases related pre surgical subjective grading via oral examination with post-surgical measurements of tonsil which included width, length, height and volume. Volume was the best correlated factor in the subjective classification and actual tonsil volume was described to differ from 2.17 - 4.7 ml (Wang et al., 2009). Children with advanced OSA had high chances of getting postsurgical airway problems. The occurrence of postoperative complications was nearly four times greater in children of age less than 3-years. In tonsillar enlargement and severe OSA subject's sonography may be used to identify and predict the severity of postsurgical complications after tonsillectomy. Anatomy of human's upper respiratory tract is highly variable, and the pathological anatomy of sleep apnea patients is even more inconstant. Furthermore the Pharyngeal anatomy of sleep apnea patient alters over time as the condition advances or recovers (Sanders, 2020).

In a prospective study that included both children and adults, explored the achievement of USG in the precise estimation of palatine volume. In the sample of 50 children the mean actual tonsil volume ± SD was 3.5 ± 1.45 ml which was evaluated through water displacement method and ultrasonographic volume was 3.67 ± 1.59 ml with positive correlation. Mean actual tonsil volume in 35 adult subjects ± SD was 5.15 ± 2.25 ml. 5.71 ± 2.98 ml was the ultrasonographic volume with moderate correlation was found between both methods (Mengi, Sağtaş & Kara, 2020). It is well identified that endophytic tonsil lead to misrepresentative of clinical grading as compared to actual volume in adults. Those subjects with lower grades were known to have greater tonsil volume than predicted during surgery. In these type of cases USG is a better option to provide true estimation of tonsil volume that may enhance considerable importance and direction on clinical follow up or operation decisions (Lai et al., 2014).

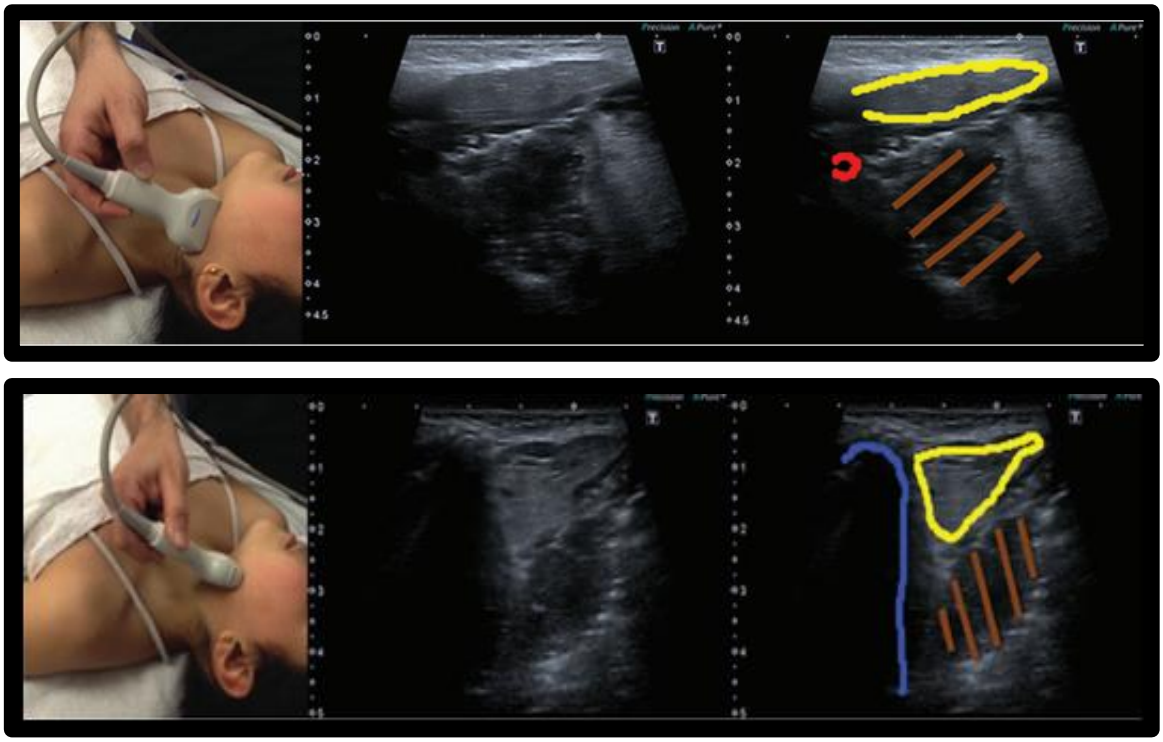


Figure 12: Trans-cervical USG of palatine tonsil, the subject is lying in supine position with head tilted away from sonologist depending upon the side to be scanned. Use of linear transducer under mandible, following structures are visualized: yellow marked as submandibular gland, red marked as external carotid artery, brown area marked as tonsils in all three planes shadow of the mandible marked as blue (Heinrich, Johannes & Alessandro, 2013).

An ultrasonographic Japanese study in which authors reported that tonsil size increases significantly until 3-years of age but it does not increases between 3 to 12 years of age, further described that tonsil size was associated with anthropometric indices like age, weight, and height, with strongest correlation with height (Hosokawa et al., 2019). Imaging, performed predominantly by physicians and research scientists, has been essential to evaluate the morphological basis of OSA. Increased collapsibility of the upper airway due to increased nasal resistance and a narrowed, elongated oropharynx leads to apnea during sleep as there is reduction in tone of the pharyngeal dilator muscles. Imaging can strongly detect this condition. The value of imaging techniques has proven its importance in assessing site, degree and reasons of airway collapsibility, its length and location of the hyoid bone. (Whyte & Gibson, 2019).

2.6 QUANTITATIVE EVALUATION OF TONSILS WITH SHEAR-WAVE ELASTOGRAPHY

Elasticity and rigidity of soft tissues can be determined by ultrasonographic elastography (Figure 13). A prospective study which included 80 healthy subjects with age ranging from 3 - 17 years determined normal elasticity and velocity values for palatine tonsils using shear wave elastography. According to authors this technique is non-invasive, more practical and easy to apply as it is not dependent on operator. Knowledge of elasticity values is important for normal and pathological differentiation of tissues. In this way it helps in diagnosis and prognosis of a disease process. Hence this technique is more practical and provides reliable data to be used routinely. For identification of normal and diseased tissue distinct symbolizations for elasticity and velocity of tissues will be helpful. Authors further notify that inflammatory process of acute and chronic nature are common manifestation of palatine tonsils but it can be confused with hyperplastic or malignant pathology. Conventional USG is in sufficient for diagnosis of the disease as it gives information regarding vascularity of tissue and size of the structure under observation only. In this condition shear wave elastography is helpful as it gives information regarding tissue texture and consistency. Results of this prospective study demonstrated little variability as the values of elastography showed normal distribution with in statistically narrow range which raises the sensitivity for

diagnosing infections, inflammatory processes and neoplastic tissues. This method is still under research as it requires larger sample size to generalize the results and to evaluate the changes in rigidity in palatine tonsils of children of growing age. Further alterations from adult populations should be studied to enhance and take benefit of the diagnostic capability of shear wave elastography. The research concluded that there was no significant association of age and BMI with shear wave elastography (Öztürk, Çaliskan, Bayramoglu & Adaletli, 2018).

2.7 ROLE OF ANTHROPOMETRIC MEASUREMENTS WITH HYPERTROPHIC TONSILS

Yagi et al., (2009) enhanced the significance of physical examination of upper airway anatomy by an ENT specialist which gave a clue for guessing the severity of OSA. Other undervalued variables like BMI, collar size, narrowness of anterior pillars, tongue and tonsillar grading should be considered as they are related with the seriousness of OSA having Apnea hypopnea index ≥ 5 in the Japanese population. A study conducted on obese children with or without OSA compared clinical features and upper airway on physical examination, questioners, and laboratory tests concludes pervasiveness OSA was higher in obese children as compared to general pediatric population whereas anthropometric measurements (neck circumference, BMI), gradation of obesity were not associated significantly with the manifestation of the disease. In distinction with assessment of upper airway with grading of palatine tonsil and modified Mallampati grade of 3 and 4 is linked with occurrence of OSA in overweight children (Martinelli et al., 2017).

A study was conducted to assess size of palatine tonsil in OSA patients and was compared with obese and normal weight subjects in which they found that despite of having same subjective size in both the study groups the objective size and mean tonsil volume of palatine tonsils was greater in obese children as compare to the control group with obstructive sleep disorder (Wang et al., 2010). A study conducted to find the effects of weight reduction on OSA demonstrated improvement in apnea hypopnea index after six months of intervention. Upon follow up apnea hypopnea index was normalized in 27 (44 %) patients out of a total 62 study participants. In accordance with multiple linear regression the decrease in apnea index was associated with decline in BMI regardless of age, sex, baseline characteristics,

stage of puberty, grading of enlarged tonsils, baseline apnea index, BMI and follow up. The authors further reported that there was no connotation between change in BMI and apnea hypopnea index until second follow-up with a p-value of 0.81. Thus concludes that treatment of obesity should be considered as first line management of patients affected by obesity. (Andersen, Holm & Homoe, 2019).

A Canadian cross sectional study determined size of tonsils, adenoid hypertrophy and height to neck ratio, as it has predictive strength for OSA and can be helpful in screening obese individuals that are at high risk. There were 53 obese individuals from 8 to 18 years of age out of which 28 study participants (53 %) were diagnosed with OSA. In accordance with logistic regression, hypertrophic tonsils were associated remarkably with OSA, (p-value 0.01) (Narang et al., 2018). Presence of pertinent alterations in upper airway anatomy can affect the patency of air passage during sleep. Therefore, it is important to identify those relevant anatomical structures during physical examination related to airway in patients with obstructive sleep disorders. A study conducted by Zonato, Bittencourt, Martinho, Junior, Gregório & Tufik, (2003) established that detailed physical examination along with BMI, modified MS, anatomical alteration of pharynx were associated to existence and severity of the disease. In this study they observed patients with nasal obstruction and hypertrophic tonsils which was related to OSA. Formally MS was used to anticipate risks associated with intubation in practice of anesthesia. Other factors such as obesity, craniofacial abnormality, extended soft palate, enlarge tonsil and higher tongue score contributes to difficult endotracheal intubation. Therefore, these facts should be considered before by surgeon and an anesthesiologist for patient safety and procedural performance. In a review article, Kitipornchai, Jones & MacKay, (2019) concluded that present available anatomical treatment strategies do not provide cure to all adults suffering from OSA whereas clinical diagnosis is limited to apnea hypopnea index severity which is also not a complete criteria. There is rising attention towards anatomical and physiological phenotyping which is related to syndrome identification. Clinical evaluation of a patient must include a detailed morphological evaluation of oropharynx with supportive physiological treatment which is evolving such as oxygen, sedatives, stimulation of hypoglossal nerve that will modify therapy options for an appropriately selected patient.

Regarding anthropometric measurements, neck circumference has gained an importance as it is simpler, easy to measure and more practical, not influenced by last meal or clothing. A Pakistani cross sectional study validates the significance of it as a measure of general and central adiposity as a screening tool for determination of obesity. This research found a cut off value for overweight subjects to be greater than 35.5 cm in men and 32 cm in women. Further collar size correlates well with other anthropometric measurements such as weight, waist circumference, age, hip circumference, waist to hip ratio, BMI for men and women (Hingorjo, Qureshi, & Mehdi, 2012). Another cross sectional study revealed neck circumference as a significant risk indicator for metabolic states and might be vital in identification of visceral and central adiposity in health care setting primarily, in primary health care units and in research projects. This anthropometric measurement should be assessed when there is non-availability of expensive instruments and various equipments. Usage of this technique is helpful in pregnant ladies in which traditional measures might become challenging or not possible (Joshipura, Muñoz-Torres, Vergara, Palacios & Pérez, 2016).

2.8 OBSTRUCTIVE SLEEP APNEA AND MEDICAL ASSOCIATIONS

Despite sleep related disorders OSA disturbs almost every system of the human body manifesting in aggressive cardiovascular, respiratory, neuroendocrine, gastrointestinal, perinatal, obstetric, linked to accidents and mortality associated health results (Espiritu, 2019). Medical associations of OSA involves the mechanism of recurrent airway obstruction either partial or complete. Reasons for the cyclical airflow restrictions linked with oxygen desaturation, re-oxygenation, changing intrathoracic pressure with subsequent hemodynamic deviations and sympathetic stimulations linked with electroencephalographic awakenings.

Disrupted nocturnal respiratory function and quality of sleep along with comorbidities manifests in oxidative stress, activation of inflammation, sympathetic system, deteriorated endothelial function, hemodynamic alterations, hormonal and neuronal modifications. These pathological processes behind OSA lead to raised morbidity and mortality (Espiritu, 2019). A meta-regression analysis revealed that subjects with obstructive OSA-hypopnea syndrome have deranged lipid profile. The study included 18,116 subjects that had raised total cholesterol, triglyceride levels, low-density lipoprotein and decreased high-density

lipoprotein, showed their relation with atherosclerosis and increased chances of cerebrovascular and cardiovascular events (Nadeem et al., 2014). A Turkish case-control study conducted to assess intraocular pressure, the thickness of the cornea and retinal nerve fiber layer thickness in OSA patient showed no statistically significant correlation between the above-mentioned parameters and disease. According to the authors, these alterations can be due to demographic features of OSA and the control group such as the duration of disease, standardizations of gauging instruments, techniques of measurements and vascular dysregulation present in subjects with OSA (Teberik, Eski, Balbay, & Kaya, 2018). It has been reported in a study conducted in Pakistan that most physicians are unaware with the clinical features and common involvement of sleep apnea, with 18 % health care providers treating sleep disturbances with tranquilizers (Hussain, Zahid, Haqqee, & Khan, 2003).

2.9 OUTCOME OF TONSILLECTOMY

In a research conducted in Brazil, the authors estimated the outcome of tonsillectomy in a group of obese subjects diagnosed with moderate to severe OSA-hypopnea syndrome with enlarged tonsils who were initially on CPAP therapy. They determined that apnea hypopnea index after the removal of tonsils reduced to 23 ± 18/h with a p-value of 0.0005 from pre-operative value of 81 ± 26/h. Therefore, a tonsillectomy might be ultimately considered as a choice of treatment when CPAP therapy compliance is reduced (Martinho et al., 2006).

Removal of diseased tonsil can decrease number of episodes of repeated sore throat, reduction in number of missed school attendance as well as usage of health care visits or facilities. This outcome does not lengthen beyond one year after surgery. Advantages of tonsillectomy are significantly declined for individuals with mild severity of disease. Literature proves post-surgical improvement in quality of life with passage of time. Moderate to severe sore throat got by some of the less affected children who underwent tonsillectomy as compared to control study participants. Therefore, authors conclude that removal of tonsils is not economical and does not contribute clinically expressive developments in children who does not meet standard criteria of tonsillectomy, in addition to it patients should be counseled on the limited advantages of surgery in patients with mild disease. (Mitchell et al., 2019).

Another study conducted in Japan in patients with immunoglobulin A nephropathy revealed that tonsillectomy is one of the treatment approaches. It was publicized by researchers that

size of the palatine tonsil cannot be counted, as a reason when deciding indication for removal of tonsil in IgA nephropathy as the therapeutic effect of surgery along with steroid pulse therapy and pathological characteristics of palatine tonsil in Ig A nephropathy were equivalent (Sato et al., 2017).

Inflammation of tonsils is the commonest disease process affecting children and adults. Various causative factors established that commonly involved bacterial or viral pathogens. Each disease process manifests in a unique way with a unique amalgamation of symptoms, clinical findings, and treatment varieties. On the basis of type of tissue inflammation and infection, morbidity can be substantial and can include local organ or distant tissues. A thorough inspection of a patient with tonsillitis involves detail account of assessment of the related anatomy, immunological function, and vulnerability to infection. Accurate diagnosis and treatment are the essential components of management of this disease process (Sidell & L Shapiro, 2012). Based on the analysis of the literature the gap in the knowledge of ultrasonographic evaluation of tonsils in Pakistan has not been studied and requires assessment of its size through this technique.

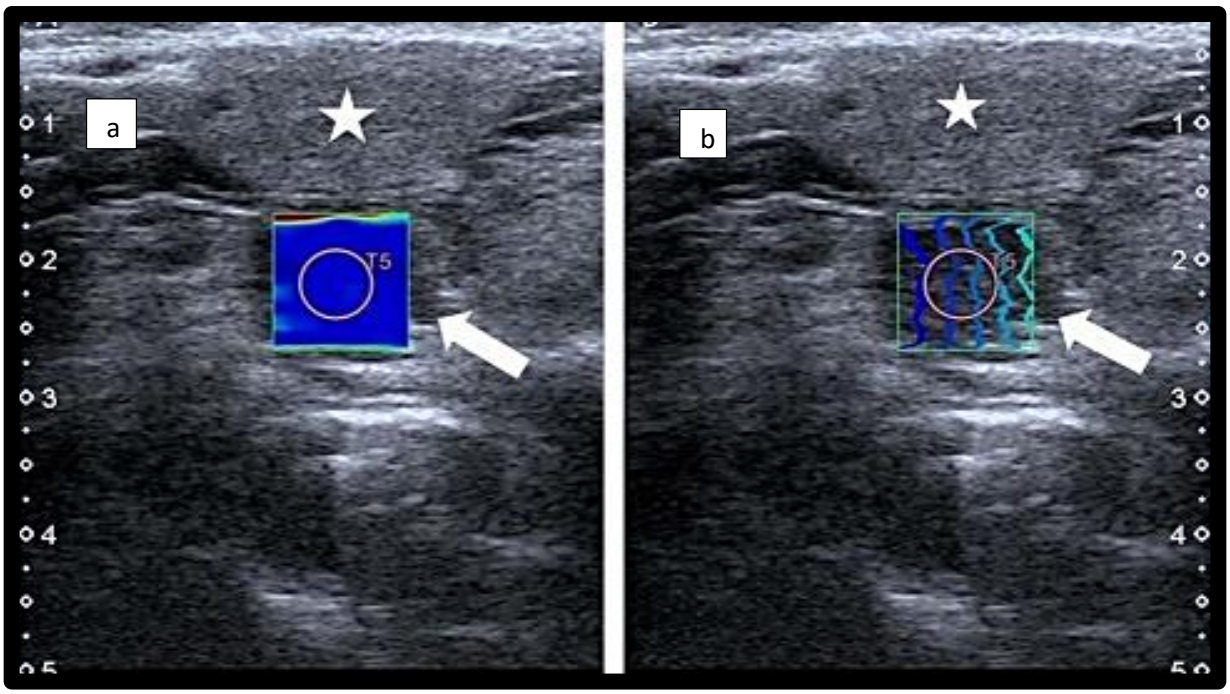


Figure 13: Shear wave elastography of left palatine tonsil (image a and b): Using linear probe of high frequency USG, white arrow indicates palatine tonsil and star shows left sub mandibular gland. Two dimensional map shown in image (a) whereas quality mode in image (b). The segment indicates parallel and smooth contour lines, a round area was placed on parenchyma (Öztürk et al., 2018).

CHAPTER 3

METHODOLOGY

3.1 STUDY DESIGN

The research design for the research project “Morphological and ultrasonographic association of tonsil grading with objective tonsil size in adults” was a comparative cross sectional study. The research evaluated the morphological parameters of tonsil grading and ultrasonographic measurements.

3.2 SUBJECTS

Human subjects, with hypertrophic tonsils were selected with age ranges from 18 years to 60 years of age.

3.3 SETTING

PNS Shifa hospital Karachi. The patients coming to the out-patient department were taken as the study participants after their written informed consent.

3.4 INCLUSION CRITERIA

Subjects fulfilling the following criteria were included in the study

- Age between 18-60 Years
- Subjects with hypertrophic tonsils

3.5 EXCLUSION CRITERIA

- Age below 18 years and above 60
- Children (They have different growth parameters for evaluation like BMI and changing size of palatine tonsils in children up to adolescence)
- OSA patient with uvulopalatopharyngoplasty (UPPP)
- Tonsillectomy
- Malignancy
- Trauma
- Women (Thyroid disorder, Cushing's disease, pregnant and lactating women)

3.6 DURATION OF STUDY

Individual study period:

06 hours of ENT OPD

Total study period**:**

- The data collection was started at PNS Shifa hospital from the month of January 2019 till June 2020
- The total duration of research was 06 months

3.7 SAMPLE SIZE ESTIMATION

The sample size was estimated using the method of sample size for frequency in a population on www.openepi.com which is an open source calculator, version 3—SSPropor. Sample size was calculated to be 45 at 95% confidence level by using prevalence of tonsillitis in general population of Pakistan as 54.54 % (Rafi, Mehboob, Aftab, Saify & Rehman, 2017).

Using following equation sample size was calculated;

Sample size n = [DEFF*Np (1-p)]/ [(d2/Z21-α/2*(N-1) + p*(1-p)]

Sample Size for Frequency in a Population

Population size (for finite population correction factor or f p c) (N): 50

Hypothesized % frequency of outcome factor in the population (p): 54.54 % +/-5

Confidence limits as % of 100 (absolute +/- %) (d): 5%

Design effect (for cluster surveys-DEFF): 1

Sample Size (n) for Various Confidence Levels

Confidence Level (%)	Sample Size
95%	45
80%	39
90%	43
97%	46
99%	47
99.9%	48
99.99%	49

3.8 SAMPLING TECHNIQUE

Non-probability consecutive sampling was used for recruiting all the patients coming to the ENT department.

3.9 HUMAN SUBJECTS AND CONSENT

Human subjects, with hypertrophic tonsils were selected. All the study subjects were explained the rationale of the study by the principal investigator of the research. They had the freedom not to participate in the study or to leave the study at any point of the research. A written informed consent was taken (Urdu and English).

3.10 MATERIALS

3.10.1 Measuring tape: For measurement of neck circumference and height (Figure 14)

3.10.2 Weighing machine: For weight measurement (Figure 15)

3.10.3 Stethoscope and Sphygmomanometer: For blood pressure evaluation (life line classic) (Figure 16)

3.10.4 Head light: For visualization of oropharynx (Med star, MH 500) (Figure 17)

3.10.5 Tongue depressor: Metallic and disposable (Microsidd wooden tongue depressor) for proper visualization of oropharynx and to depress the tongue (Figure 18)

3.10.6 Ultrasound machine: Toshiba Aplio 500 (Figure 19)

3.10.7 Transcervical ultrasound-high frequency probe**:** Curvilinear-13.6 Megahertz (Figure 20)

Figure 14: Measuring tape used for measurement of neck circumference and height of the study participants

Figure 15: Weighing machine for estimation of weight of study participants

Figure 16: Stethoscope and Sphygmomanometer for blood pressure evaluation

Figure 17: Head light used for illumination of oral cavity (PNS Shifa hospital-ENT department)

Figure 18: Tongue depressor (wooden and metallic) at PNS Shifa hospital-ENT department

Figure 19: Ultrasound machine (PNS Shifa hospital-Radiology Department)

Figure 20: High frequency- Curvilinear probe (PNS SHIFA Hospital-Radiology department)

3.11 STUDY PARAMETERS

Patients with hypertrophic tonsils were recruited by experienced otorhinolaryngologist. After taking informed consent physical examination was procured which included morphological features classification of tonsils as follows

3.11.1 TONSILLAR GRADING: Brodsky tonsillar grading was used in the present study. The morphological features were evaluated while the patients were sitting calmly with spontaneous breathing. Tonsils were graded as follows

Grade 0: Tonsils within the tonsillar fossa or removed

Grade I: Less than 25 % of the oropharynx occupied (Figure 21-a)

Grade II: 25 % to 50 % occlusion of oropharynx (Figure 21-b)

Grade III: 50 % to 75% of the oropharynx occupied (Figure 21-c)

Grade IV: Greater than 75 % of the oropharynx occupied completely obstructing the airway (Figure 21-d)

3.11.2 TONGUE GRADING: Tongue grading was done by Mallampati scoring (MS), which is as follows

Grade I: Clear visualization of tonsils, pillars and soft palate (Figure 21 a and b)

Grade II: Visibility of uvula, pillars and upper pole (Figure 21-c and d)

Grade III: Partly visible soft palate whereas invisible tonsils, pillars and base of uvula

Grade IV: Visibility of hard palate only

3.11.3 CALCULATION OF BMI: Weight was measured with light clothing and without shoes. Height was measured without shoes. BMI was calculated by dividing weight kilograms with the square of height in meters

3.11.4 NECK CIRCUMFERENCE (cm): By using non flexible plastic tape, neck circumference was measured in the midline below the laryngeal prominence and perpendicular to the long axis of the neck. The minimal circumference was recorded to the nearest 0.1 cm, while the subject was asked to look straight with shoulders down but not bent.

Care was taken not to include neck/shoulder muscle such as trapezius in the recording of measurement.

3.11.5 EPWORTH SLEEPINESS SCALE (ESS): Those study participants who complained of excessive day time sleepiness, snoring, restlessness and were obese, a questionnaire was used to calculate ESS. Questionnaire was filled by the principal investigator by asking the subject's questions mentioned and grading was assessed accordingly. This evaluated the subject's general level of day time sleepiness.

3.11.6 ULTRASOUND FINDINGS: Trans-cervical USG tonsillar size/volume assessment was done by the following technique as described.

POSITIONING OF PATIENT: Supine with extended neck during scanning

TRANSDUCER USED: A 13.6 MHz ultrasound probe was used (ultrasound machine of Toshiba Aplio 500) to visualized tonsillar tissue and measure its volume (Figure 20)

SCANNING APPROACH: The probe was placed just below the mandible in a plane slightly oblique to the transverse plane. Figure 22 shows positioning of probe on both sides of patient at which tissue was identified. The submandibular gland was located first followed by the external carotid vessel lateral and deep to it. Palatine tonsils were located in between these two structures are hypoechoic as compare to submandibular gland. Scanning was performed at one side at a time, first performed on right and then on left. Gray-scale tonsillar images were noted and length, width and height were measured to calculate the volume.

VOLUME CALCULATION: Three Distances measured at 90 degrees to each other and volume was calculated using a standard ultra-sonographic formula (length X width X height X 0.523) as depicted in figure 23. In the formula 0.523 is the USG constant used for ellipsoid structures.

a) Asymmetric tonsillar enlargement (Left),Brodsky grade I on the right side, MS grade I

b) Brodsky grade II on the right side, MS grade I

c) Brodsky grade III (Bilateral), MS grade II

d) Brodsky grade IV (Kissing tonsils), MS grade II

Figure 21: Grading done according to Brodsky tonsillar hypertrophy classification and Mallampati grading for tongue.

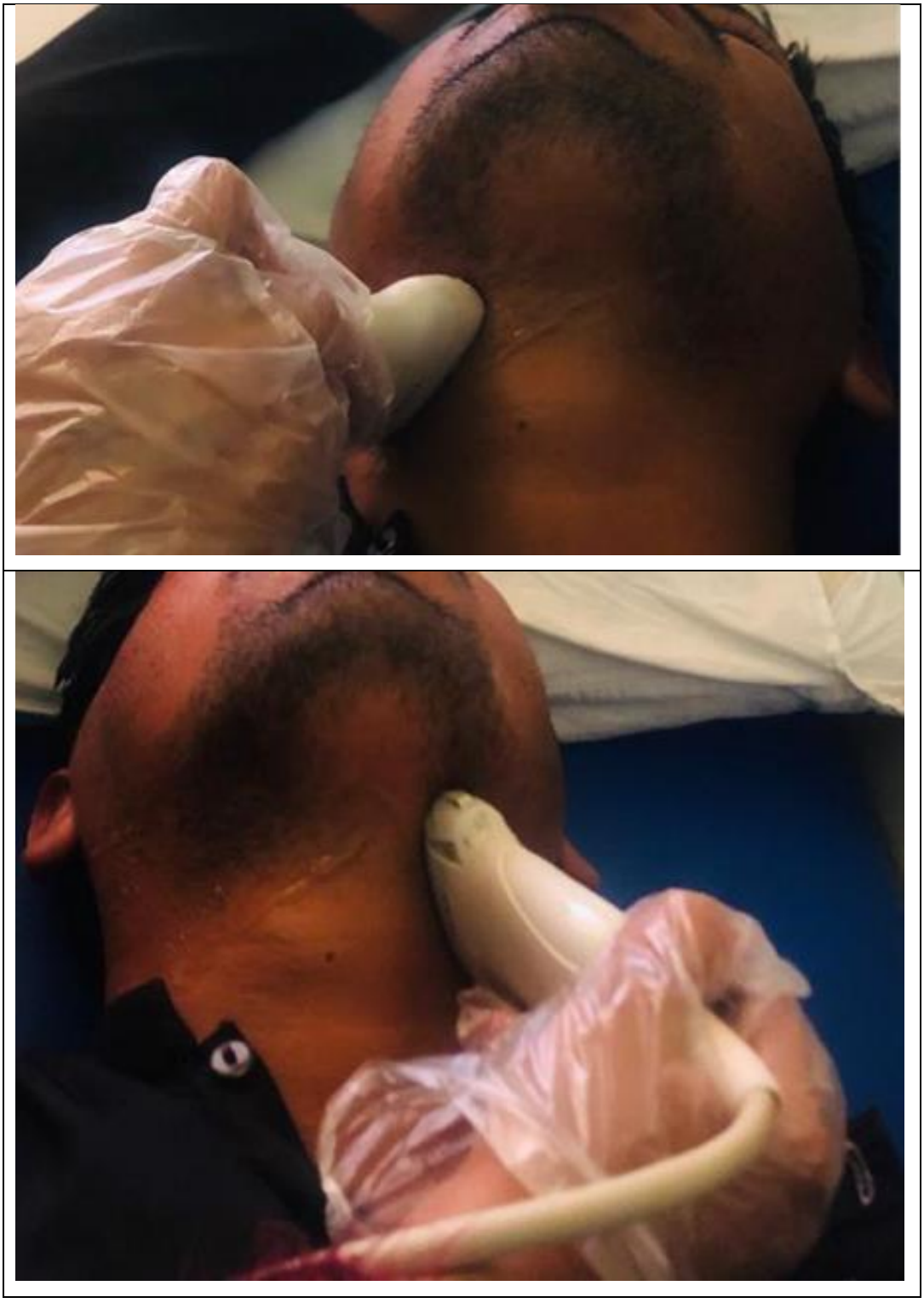


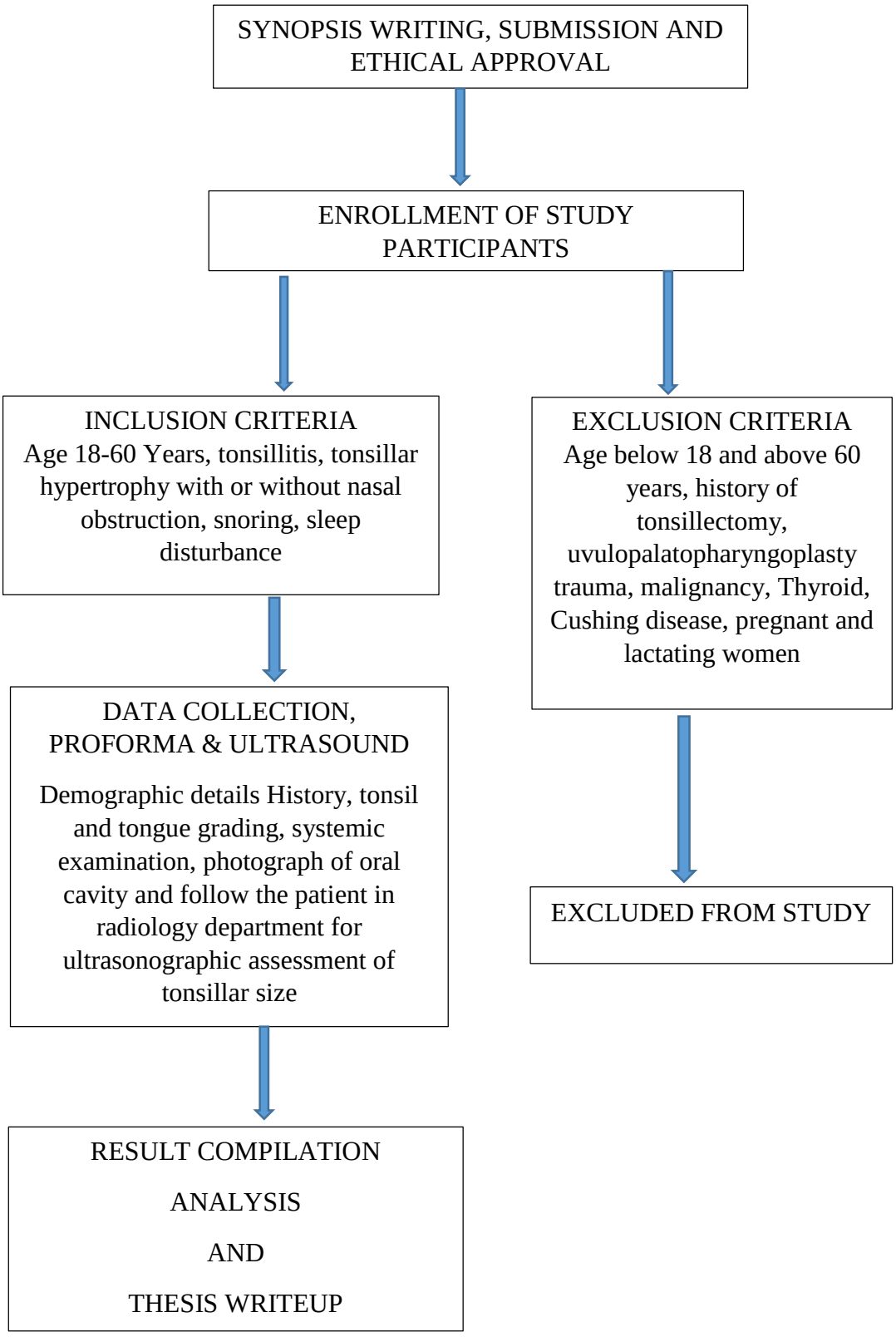
Figure 22: Demonstration of probe positioning to obtain ultrasound image of palatine tonsil

Figure 23: Ultrasonographic volume measurement of tonsil

3.12 PROTOCOL OF STUDY

This prospective study was done in agreement with Declaration of Helsinki. The study involved 54 participants with age ranges from 18 to 60 years. After taking written informed consent from the study participants, the subject evaluation Proforma (attached as an annexure) was filled by the principal investigator which included a brief history obtained by each subject, details of demographic data, history of co-morbidities, sleep disturbance, Epworth sleepiness scoring, snoring subjective scale, was done and filled for each subject. The physical examination was done which included tonsillar grading and tongue grading by otorhinolaryngologist first and then by the principal investigator to decrease subjectivity. Measurements like collar size, weight, height, blood pressure was noted and photograph of the oral cavity after their consent was taken for the record. USG measurements was noted. The data collection was completed from August 2019 to March 2020. Analysis of data and result compilation was performed in a month, followed by thesis compilation. The total duration of the study was 08 months.

3.13 ALGORITHM OF STUDY



3.14 STATISTICAL ANALYSIS

SPSS version 23.0 was used for data analysis. Results were expressed as mean ± standard deviation for Quantitative variables and number (percentages) for qualitative variables. The data was analyzed for normality. Categorical data was entered and the association between Brodsky tonsillar grading and ultra-sonographic measurements was obtained using Kruskal Wallis test, in order to determine statistically significant differences between them. Right and left side was analyzed and compared separately for tonsils. Fischer exact test was used to see association of Brodsky tonsillar grading with gender, nasal obstruction, MS and ESS, BMI with snoring and modified Mallampati scoring with BMI. One way ANOVA was used to analyze relationship between Brodsky tonsillar grading with age, weight and association of USG volume of tonsil with BMI. Independent sample t-test was used to see association of USG size of tonsil with age, gender, neck circumference and ESS. In order to see association of MS with ESS, Pearson Chi square was used. To determine association of MS with USG volume Kruskal Wallis was used. p-value ≤ 0.05 was considered statistically significant.

CHAPTER 4

RESULTS

4.1 BASELINE DEMOGRAPHIC CHARACTERISTICS

A total of 54 adult patients were considered in this study which was conducted at ENT department of PNS Shifa. It was found that majority number of patients were males 29 (54 %) whereas 25 (46 %) were female. There were 47 (87 %) patient ≤ 35 years and 7 (13 %) patients ≥ 35 years. Regarding male gender there were 25 (46 %) patients ≤ 35 years and 4 (7 %) patients ≥ 35 years, and regarding female gender there were 22 (41 %) patients ≤ 35 years and 3 (6%) patients ≥ 35 years (Figure 24). The mean age was 25.72 ± 7.9 SD. It was observed in the current study that major portion of study participants comprised of 24 (44 %) male government employees, 20 (37 %) students, 9 (17 %) house wives and 1 (2 %) female government employees (Figure 25).

4.2 RESULTS FOR PERSONAL HISTORY QUESTIONS

When inquiring patients regarding addiction it was observed in present study that 15 (28 %) patients were smokers, 7 (13 %) were beetle nut chewers, 2 (4 %) were addicted to naswar whereas 30 (55 %) were not addicted to anything (Figure 26). Nine (17 %) study participants were found to be hypertensive (Figure 27). History questions involved symptom of snoring which was found to be 24 (44 %) whereas 30 (56 %) was non snorers (Figure 28). In accordance with the ESS questionnaire, 16 patients (30 %) had symptoms of excessive day time sleepiness (ESS score >10), remaining 38 patients had an ESS < 10 (Figure 29). VAS scoring for nasal obstruction was done which showed 21 (39 %) mild, 27 (50 %) moderate and 6 (11 %) severe subjective evaluation of nasal obstruction (Figure 30).

4.3 ANTHROPOMETRIC MEASUREMENTS

1 (3 %) individual had neck circumference ≥ 42 cm whereas 28 (97 %) had ≤ 42 cm in males (Figure 31). 8 (32 %) individuals had neck circumference ≥ 37.5 cm whereas 17 (68 %) had ≤ 37.5 cm in females (Figure 32). In the present study 31 (57 %) participants were found to have normal BMI, 14 (26 %) individuals were overweight whereas 9 (17 %) were obese (Figure 33).

4.4 ANATOMICAL DATA

Tongue grading was performed according to Mallampati scoring system in which there were 27 patients reported to OPD were of Mallampati grade I, 20 individuals were of grade II, and 7 study participants were of grade III. Grade IV was not observed in any of the study participants (Figure 34).

According to Brodsky grading for tonsillar enlargement the patients were graded accordingly. Maximum number of patient presented to OPD with tonsil grade II and III. For the right tonsil there were 3 (5.5 %) patients with grade I, 32 (59.2 %) patients with grade II, 16 (29.6 %) patients with grade III and 3 (5.5 %) patients with grade IV tonsillar enlargement (Figure 35). For left tonsil, 2 (3.7 %) patients with grade I, 28 (51.8 %) patients with grade II, 18 (33.3 %) patients with grade III and 6 (11.1 %) patients with grade IV tonsillar enlargement (Figure 36). Thirty one (57.40 %) out of 54 patients have had asymmetric tonsils (Figure 37). Maximum number of patients were with acute tonsillitis in this study 26 (48.1 %), recurrent tonsillitis 22 (40.7 %) and least number of patients with obstructive sleep apnea 6 (11.1 %) (Figure 38).

4.5 ASSOCIATION OF BRODSKY GRADING WITH ULTRASONOGRAPHIC VOLUME OF TONSIL

The present study discovered a highly statistically significant linkage between Brodsky grading and ultrasonographic volume of tonsil and showed a strong relationship between the

two, p-value < 0.001. Mean USG volume ± SD for right tonsil was 1.22 ± 0.88 ml and for left tonsil was 1.16 ± 0.64 ml. Individual volumes for each grade are shown in table 3.

Standard box plot for each Brodsky grade for right and left tonsil (figure 39 and 40), in which middle line shows median, the box ranges from 25^{th} to 75^{th} percentile representing interquartile range. The whiskers covers the highest (4 ml for right and 3 ml for left tonsil) and lowest (0.1 ml for right and 0.2 ml for left tonsil) observation for USG volume and points representing outliers. Present study revealed noteworthy differences showing that USG volume increases with clinical grading of tonsil. Grade I was found to be minimum with no high ranges of USG volume. Grade IV was very high in USG volume. However none of the grade shows normal behavior. Volume overlapping can be observed in figure 40 between grade II and III.

4.6 ASSOCIATION OF BRODSKY TONSILLAR GRADING WITH AGE, GENDER, WEIGHT, BMI AND NECK CIRCUMFERENCE

It was found in the present study that age associates significantly (p-value 0.0009) with Brodsky tonsillar grading for right tonsil whereas statistical non significance was found for left tonsil (p-value 0.25) as shown in table 4. There was no statistically significant correlation between subjective grading of tonsils and gender (male n = 29 and female n =25) (p -value 0.079 and 0.343, respectively), as demonstrated in table 5. When Brodsky tonsillar grading was compared with weight significant correlation was found between weight and right tonsil grading p-value 0.017 whereas non-significant for left tonsil p-value 0.085 as demonstrated in table 6. Significant correlation was found between Brodsky grading for right tonsil (p-value 0.014) and BMI. Statistically non-significant correlation was found between Brodsky grading for left tonsil (p-value 0.216) and BMI. Thirty one study participants were found to have normal BMI, 14 were overweight whereas 9 individuals were obese (Table 7). Regarding neck circumference and subjective grading, significant relationship was found between them for right and left tonsil with p-value 0.002 and 0.014 respectively as shown in table 8. Differences between right and left side can be due to presence of asymmetric tonsil in the present study participants.

4.7 ASSOCIATION OF BRODSKY TONSILLAR GRADING WITH NASAL OBSTRUCTION AND EPWORTH SLEEPINESS SCALE

VAS for nasal obstruction was designed to assess individual's level of nasal obstruction due to any pathology and was correlated with Brodsky tonsillar grading, which showed non-significant result for the right tonsil p-value 0.077 whereas significant for the left one p-value 0.024 as shown in table 9. Regarding ESS statistically significant result was found for the right tonsillar subjective grading p-value 0.00 whereas non-significant result for left side p-value 0.14 as depicted in table 10.

4.8 RELATIONSHIP OF EPWORTH SLEEPINESS SCALE, NASAL OBSTRUCTION AND BODY MASS INDEX WITH MALLAMPATI SCORING

In the current study statistically significant relationship was found between MS for tongue with VAS for Nasal obstruction (p-value 0.006) and BMI (p-value 0.003) analyzed via Fischer exact as shown in table 11 and 12. For Mallampati grade I, II and III highest individuals with mild nasal obstruction were 14 (66.7 %), for moderate nasal obstruction were 13 (48.1 %) and for severe nasal obstruction were 4 (66.7 %) as demonstrate in table 11. There was no study participant with Mallampati grade IV. The highest value was found to be in obese study individuals that is 5 (55.6 %) for Mallampati grade III as demonstrated in table 12.Regarding ESS, Chi square test was used and highly significant association was found with MS, p-value 0.013, individuals with sleep disordered breathing was found to be with Mallampati grade II, 7 (43.8 %) and III, 5 (31.3) respectively as shown in table 13.

4.9 ASSOCIATION OF BODY MASS INDEX WITH SNORING AND NECK CIRCUMFERENCE

When BMI was compared with 24 snorers and 30 non snorers significant results were obtained that is p-value 0.001. Out of 24 snorers, maximum number of snorers fall in the category of overweight 10 (41.7 %). There were 7 (29.2 %) snorers that were categorized as obese and 7 (29.2 %) participants were categorized as normal BMI as presented in table 14.

Regarding Neck circumference, when it was compared with BMI in 29 males it was observed that there was only one individual who had neck circumference greater than 42 cm that falls in BMI category of overweight, rest of the 28 individuals have neck circumference less than 42 cm and fall in BMI category of normal 20 (71.4 %), over weight 7 (25 %) and obese 1 (3.6 %). Therefore, regarding male gender insignificant p-value 0.310 was found as depicted in table 15.1.

Neck circumference in 25 females when compared with BMI shows that there were 8 individuals who were having neck circumference greater than 37.5 cm out of which there were 7 (87.5 %) in obese category and 1 (12.5 %) in overweight category. There were 17 females who had neck circumference less than 37.5 cm, out of which 11 (64.7 %) females fall into the category of normal BMI, 5 (29.4 %) were overweight and 1 (5.9 %) was obese. In this way a significant finding for neck circumference in females with p-value 0.001 was found when compared with BMI, as shown in table 15.2.

4.10 SURGERY INDICATIONS IN THE PRESENT STUDY

There were 21 (39 %) patients in this study who had undergone tonsillectomy due to various indications which include 16 (76 %) patients with recurrent tonsillitis whereas 5 (24 %) individuals had obstructive sleep apnea as demonstrated in figure 41.

4.11 ASSOCIATION OF ULTRASONOGRAPHIC VOLUME WITH AGE, GENDER, NECK CIRCUMFERENCE AND BMI

Independent sample t-test was applied to see the significance of age, gender and neck circumference with USG volume. Statistically non-significant results were found between USG volume of both tonsils with age, p-value 0.29 for right and 0.79 left tonsil. For the right USG tonsillar volume with gender significant p-value 0.01 was found but for the left USG tonsillar volume non-significant p-value 0.082 was obtained. Regarding neck circumference in female, significant association p-value 0.01 was found for the left tonsillar volume and in males significant association was obtained for right and left tonsils, p-value 0.003 and 0.0001 respectively as presented in table 16.

In order to see the significance of BMI with ultrasonographic volume One Way ANOVA was used, it was found that both USG tonsillar volume relates well with BMI having p-value of 0.01for right and 0.002 for left tonsil respectively as demonstrated in table 17.

4.12 ASSOCIATION OF ULTRASONOGRAPHIC VOLUME WITH EPWORTH SLEEPINESS SCALE AND MALLAMPATI SCORING

In order to see an association between ESS and USG tonsillar volume independent t-test was applied and a highly significant association between the two variables was found, p-value for the right 0.001 and p-value 0.001 for the left tonsil respectively as shown in table 18. In the present study association of MS was also found highly significant for right and left USG tonsillar volume with p-value 0.009 and 0.001 respectively as depicted in table 19.

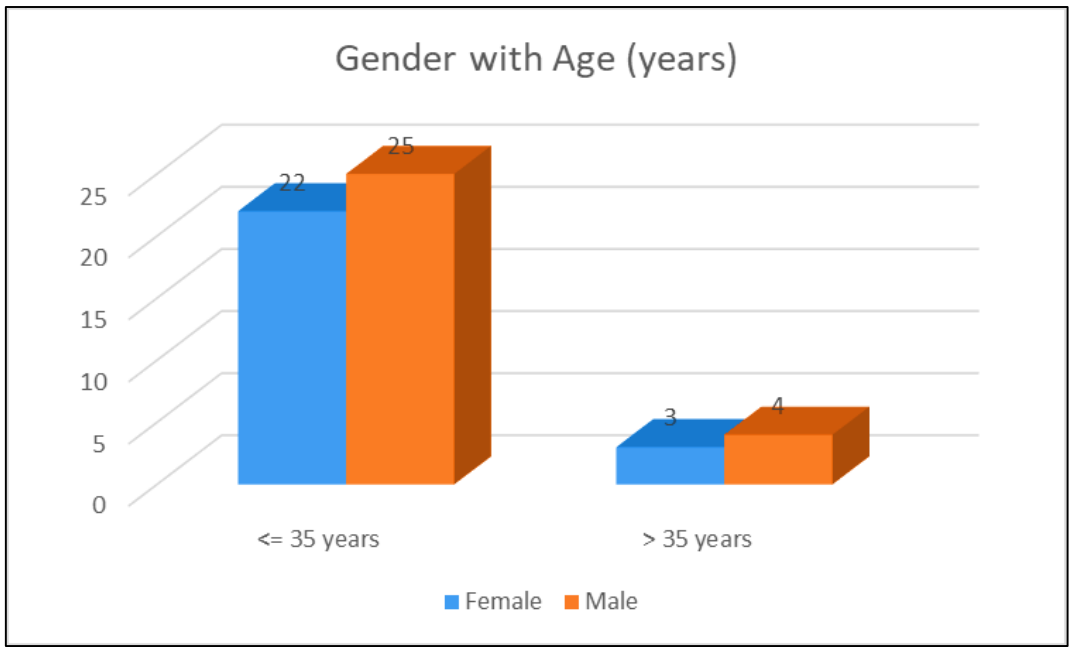


Figure 24: Compound bar presenting distribution of gender with respect to age (years)

Figure 25: Bar chart displaying distribution of profession among study participants

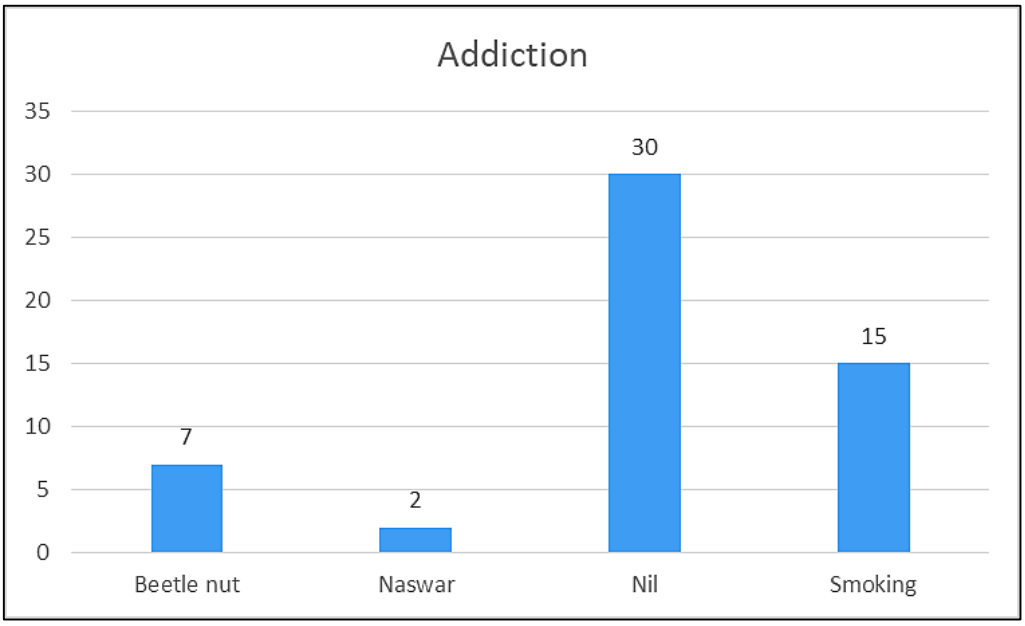


Figure 26: Bar chart depicts distribution of patients regarding addiction

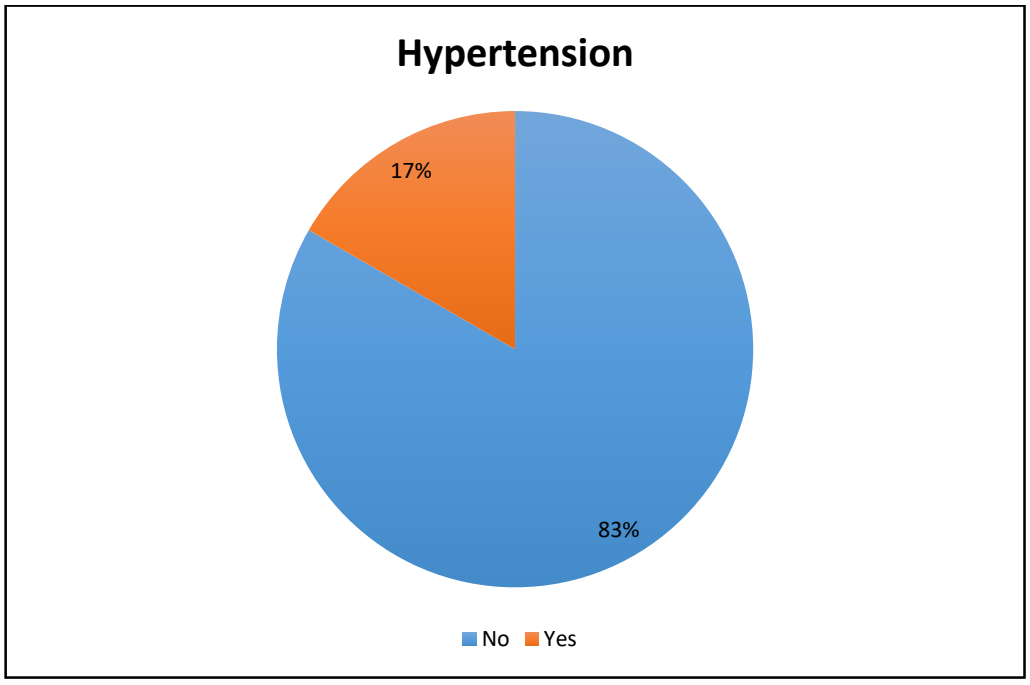


Figure 27: Pie chart showing distribution of patients regarding hypertension

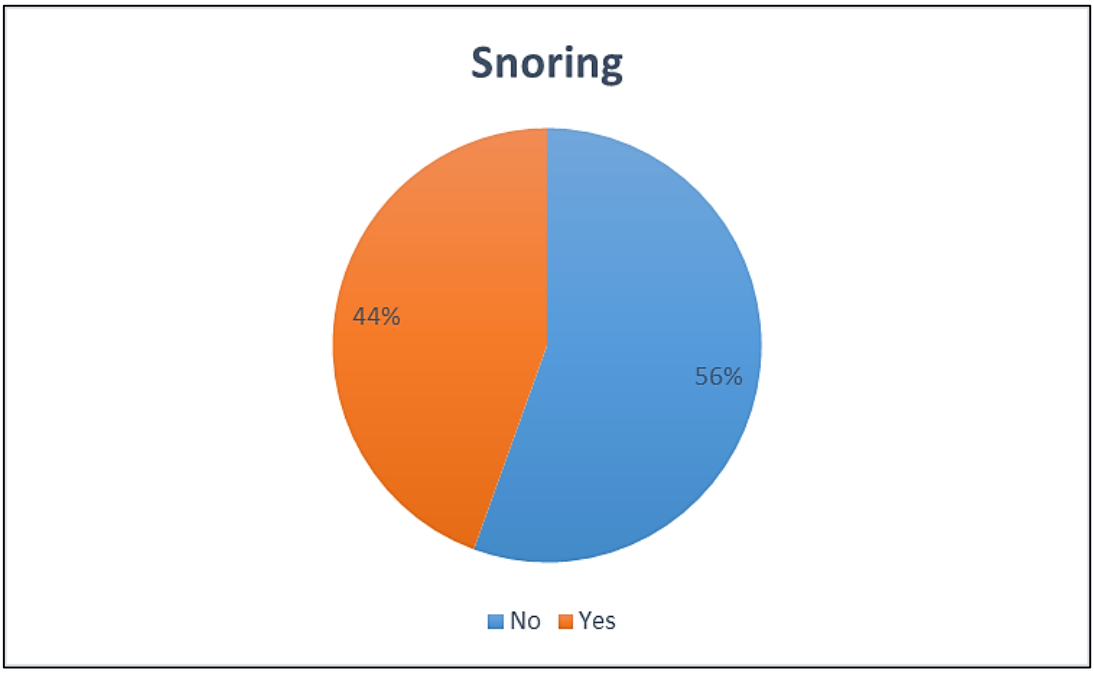


Figure 28: Pie chart showing distribution of snorers and non-snorers

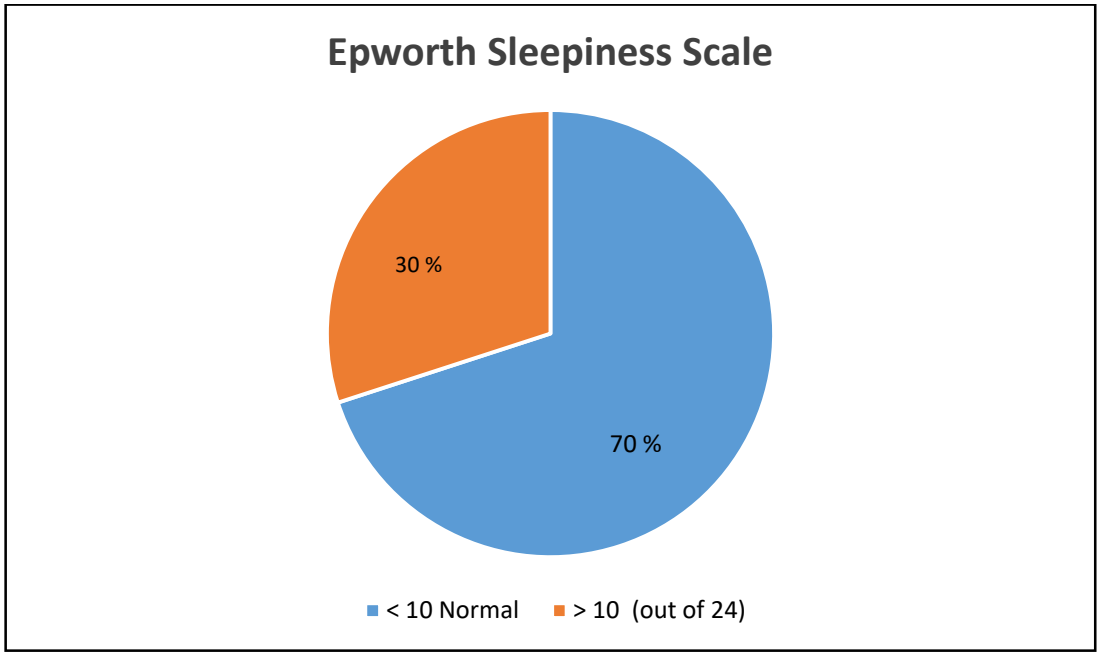


Figure 29: Pie chart showing distribution of ESS scoring

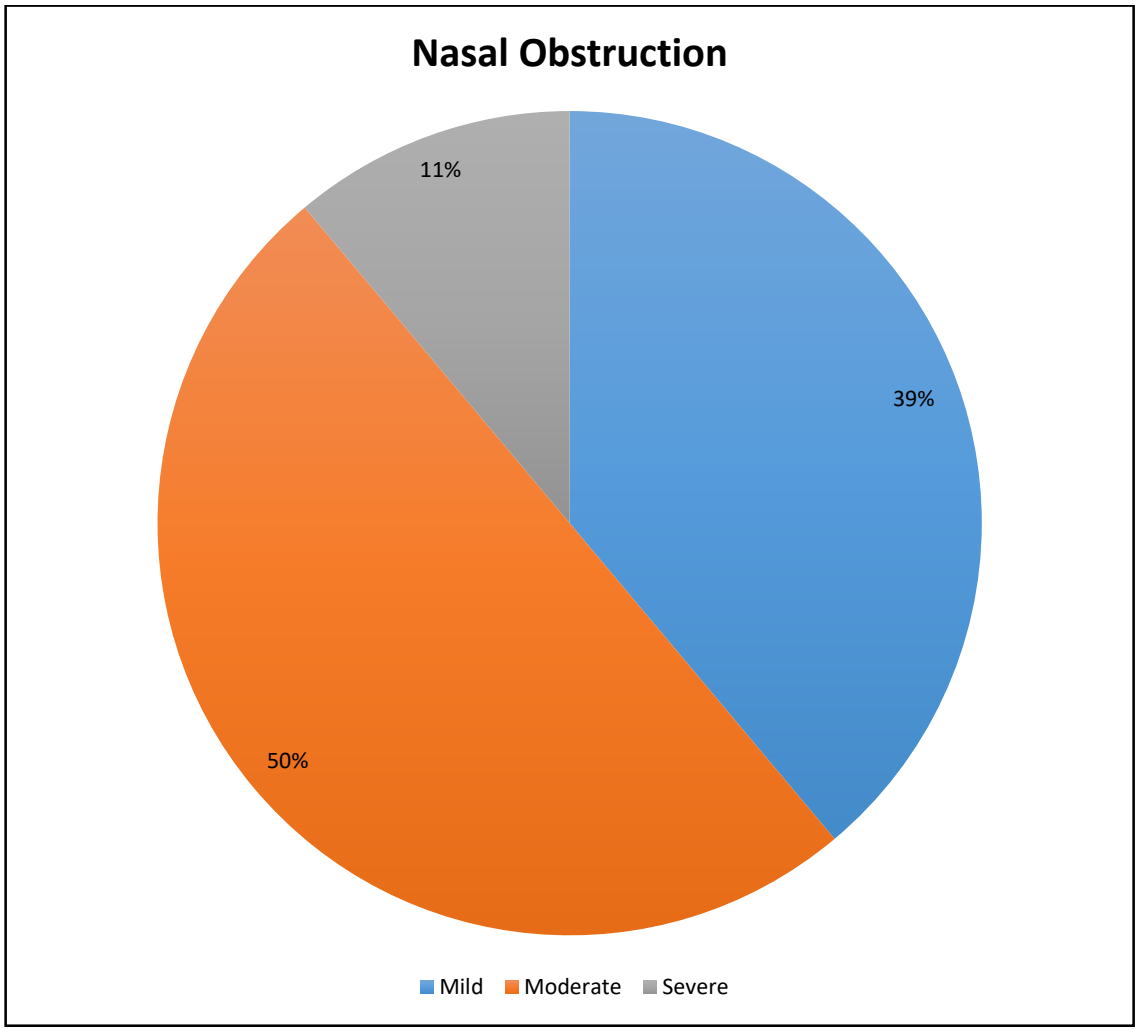


Figure 30: Pie chart showing VAS scoring for nasal obstruction

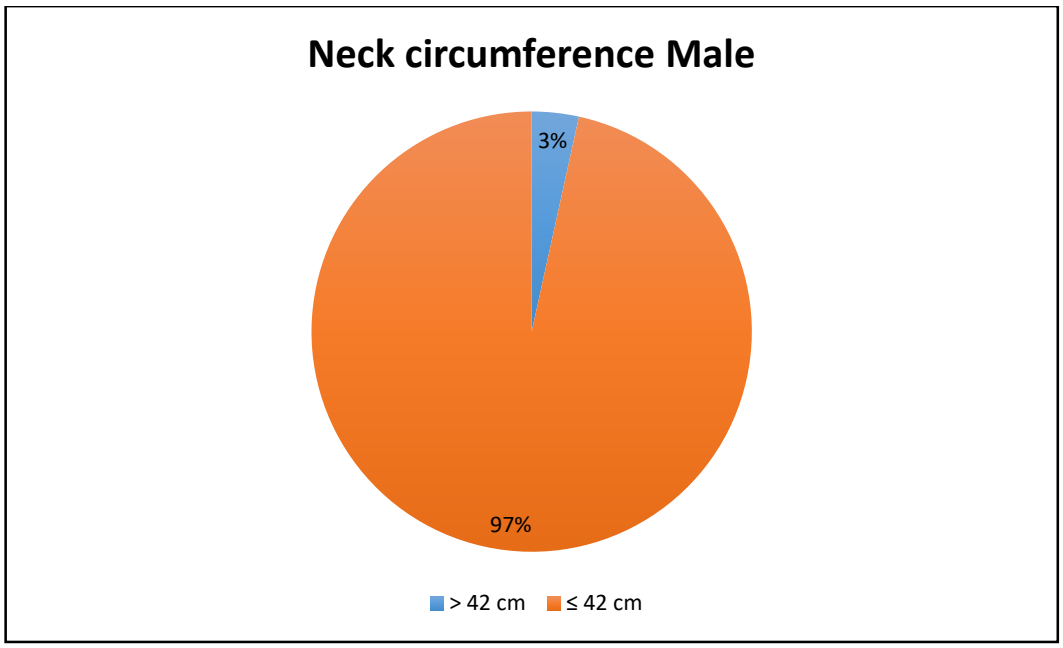


Figure 31: Pie chart showing distribution of male study participants having neck circumference ≤ and ≥ 42 cm

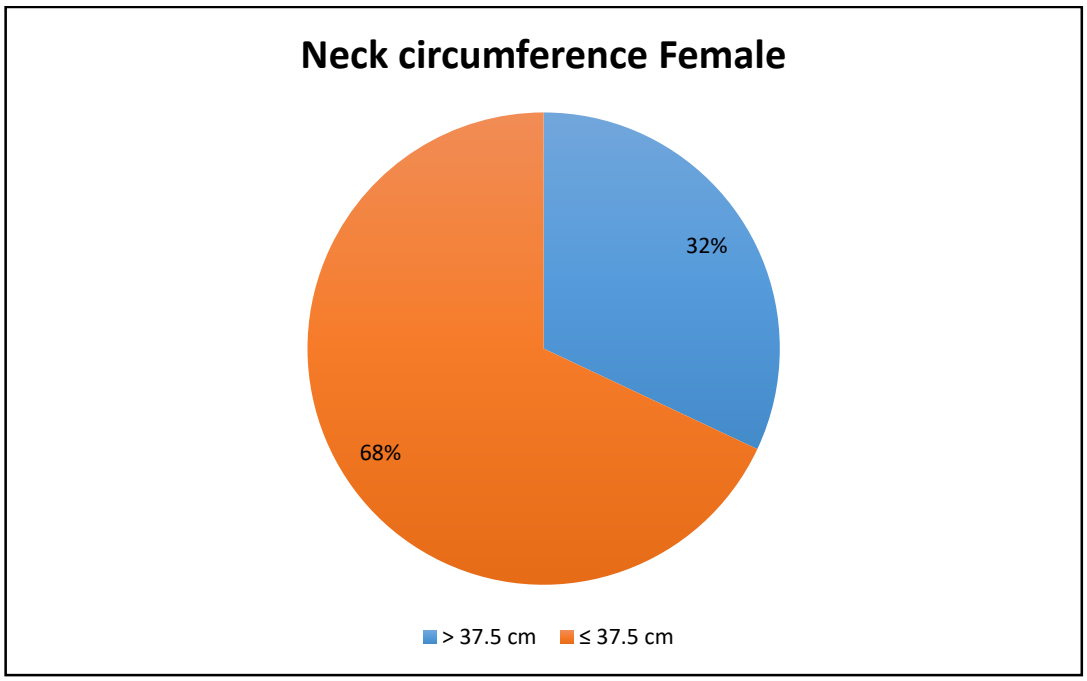


Figure 32: Pie chart showing distribution of female study participants having neck circumference ≤ and ≥ 37.5 cm

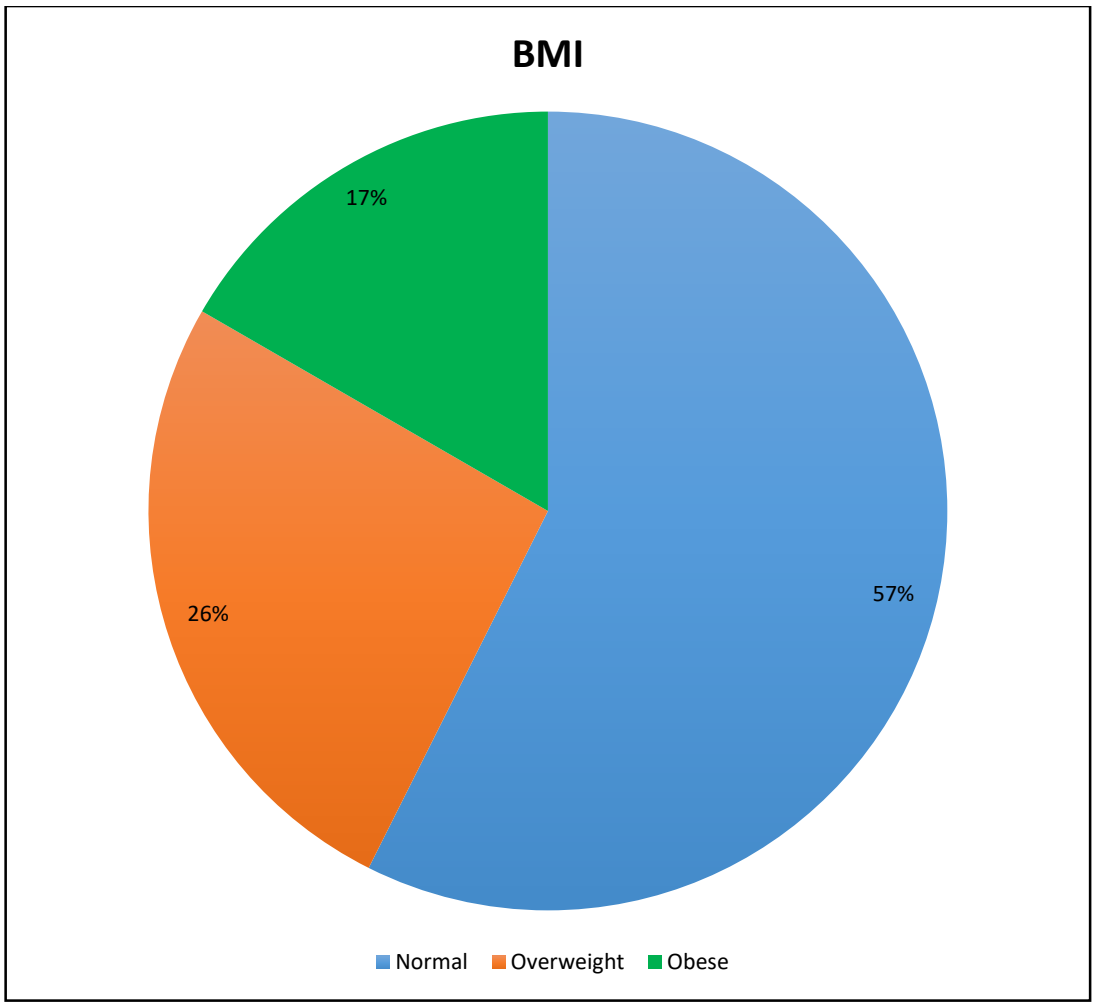


Figure 33: Pie chart showing distribution of different categories of BMI among study participants

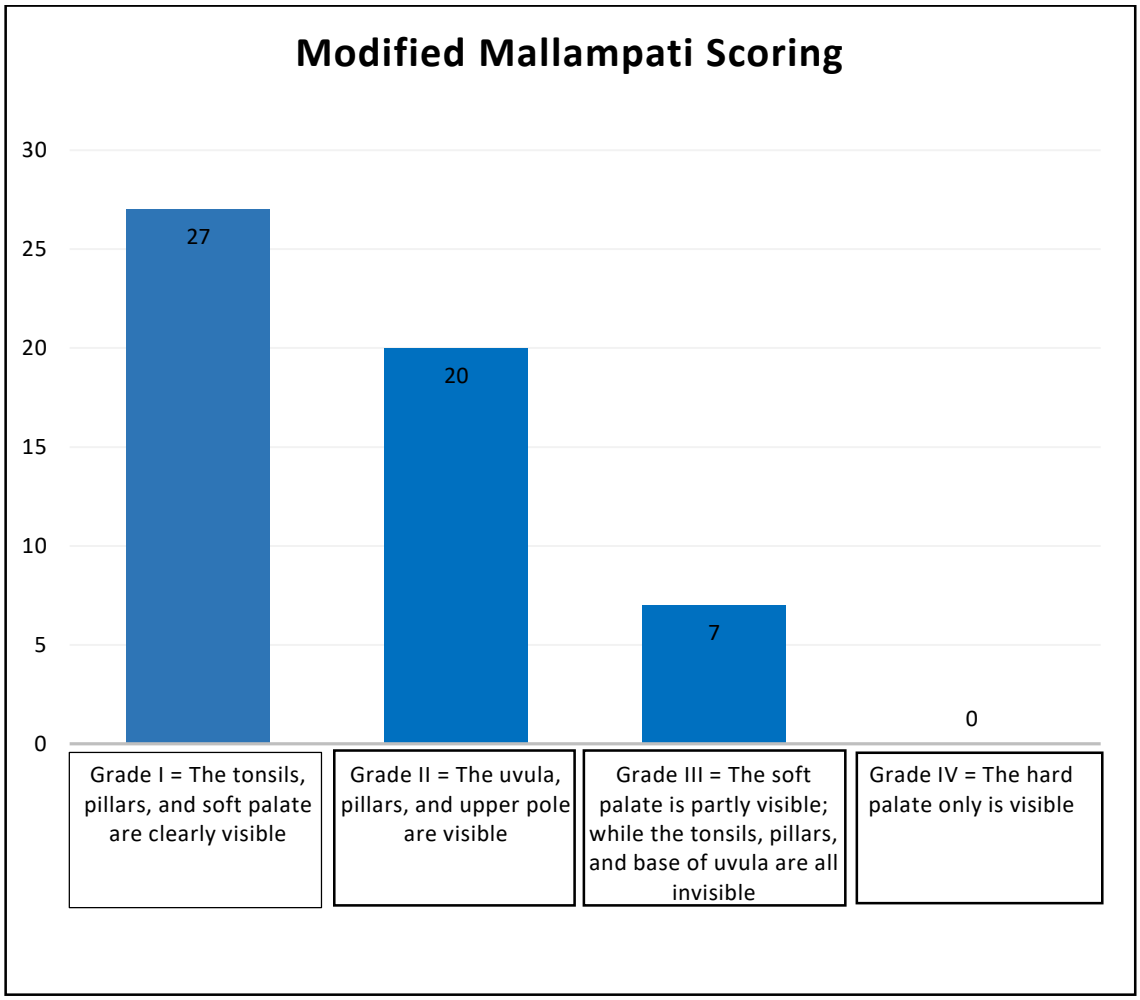


Figure 34: Bar chart representing number of patients for each Mallampati grade

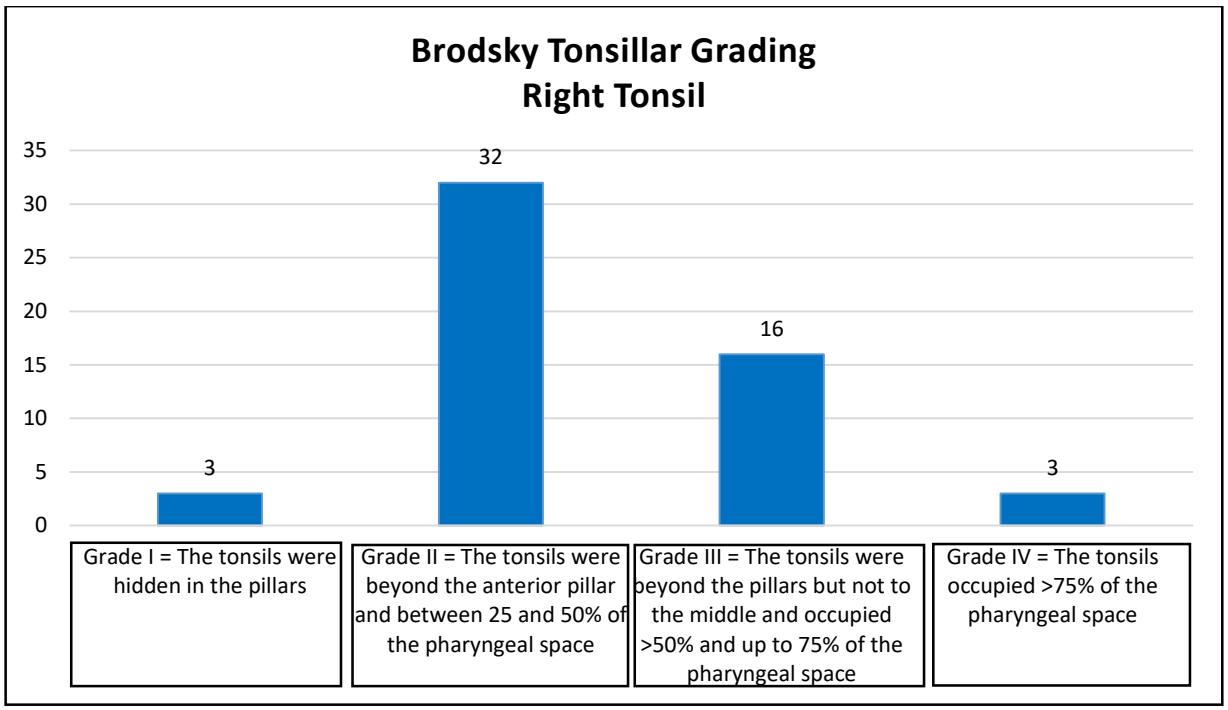


Figure 35: Bar chart showing distribution of tonsillar grading (Right)

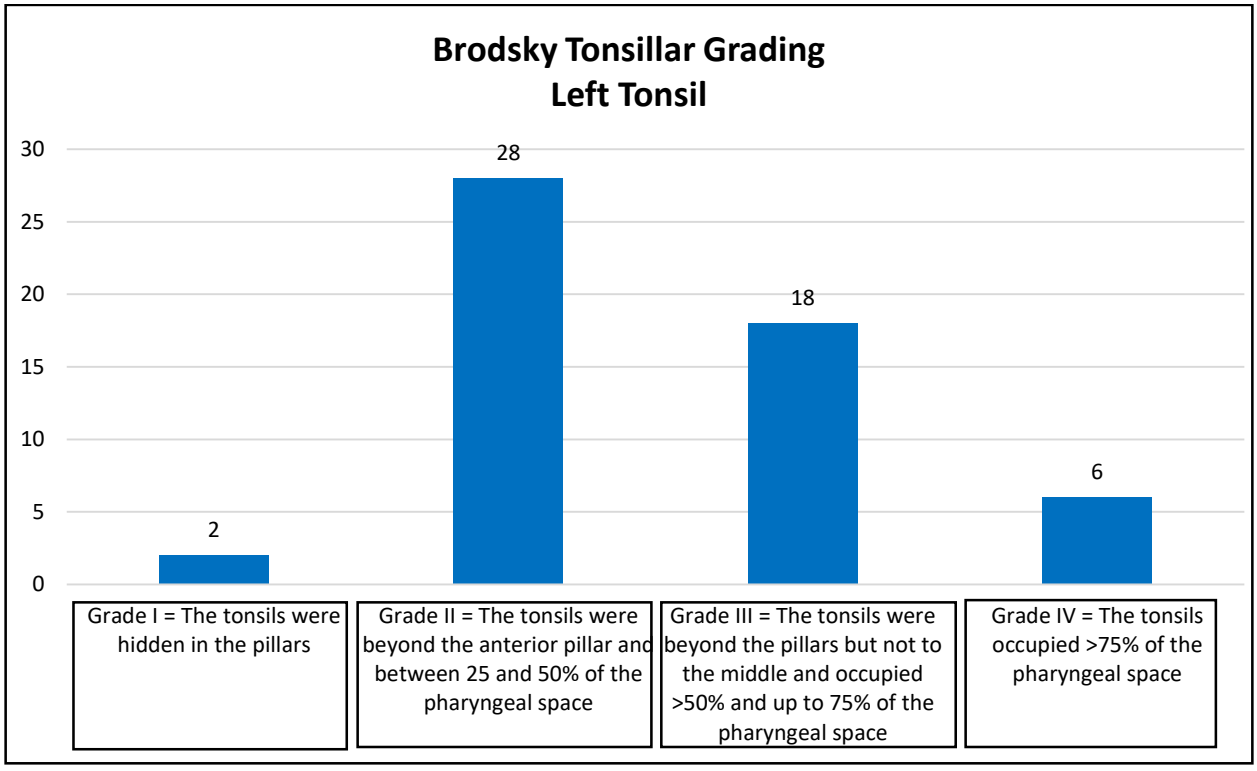


Figure 36: Bar chart showing distribution of tonsillar grading (Left)

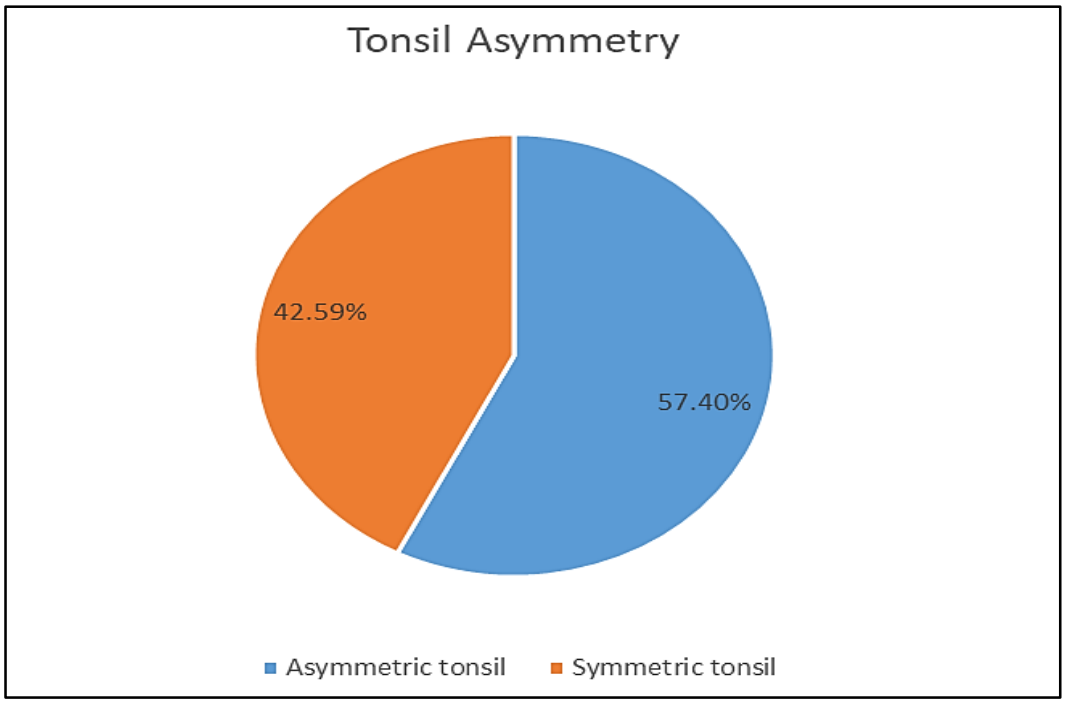


Figure 37: Pie chart showing distribution of symmetric and asymmetric tonsils

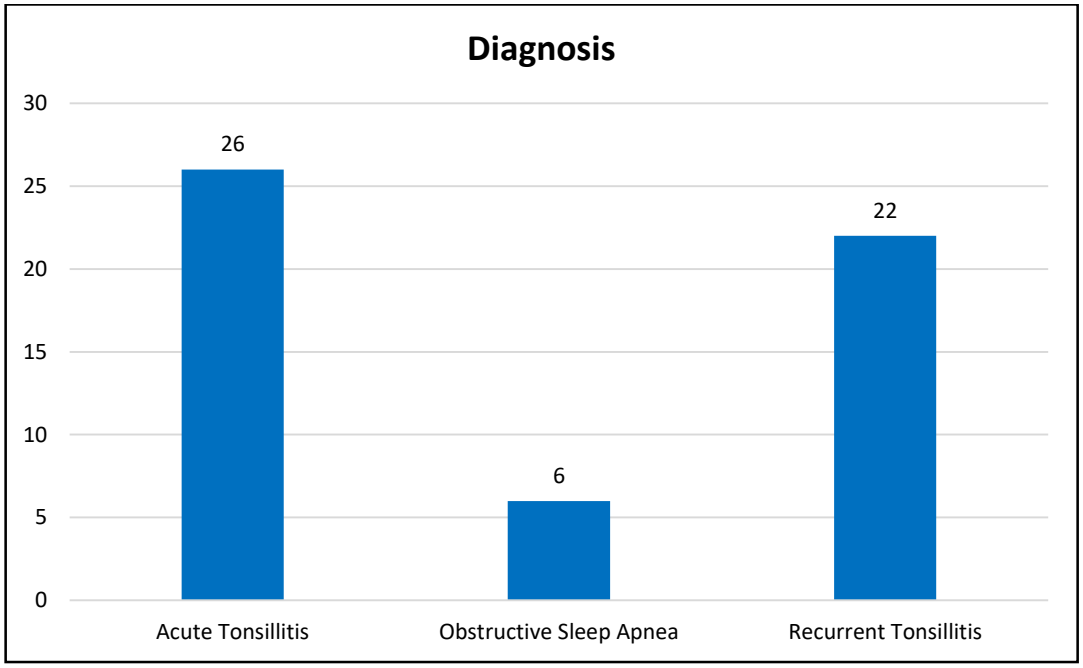


Figure 38: Bar chart showing distribution of diagnosis of patient in the current study

Table 3

Association of Brodsky Tonsillar Grading With USG Volume of Tonsil

N=54

Brodsky Tonsillar Grading	**USG Right Tonsil Volume (ml) Mean ± SD**	**p-value**
Grade I: Tonsils were hidden in the pillars	0.23 ± 0.14	
Grade II: Tonsils were beyond the anterior pillar and between 25 and 50 % of the pharyngeal space	0.77 ± 0.30	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied >50 % and up to 75% of the pharyngeal space	2.03 ± 0.89	0.001 * §
Grade IV: Tonsils occupied >75 % of the pharyngeal space	2.73 ± 0.20	
Overall	1.22±0.88	
Brodsky Tonsillar Grading	**USG Left Tonsil Volume (ml) Mean ± SD**	**p-value**
Grade I: Tonsils were hidden in the pillars	0.60 ± 0.14	
Grade II: Tonsils were beyond the anterior pillar and between 25 and 50 % of the pharyngeal space	0.86 ± 0.37	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied > 50 % and up to 75 % of the pharyngeal space	1.28 ± 0.44	0.001 * §
Grade IV: Tonsils occupied >75 % of the pharyngeal space	2.41 ± 0.62	
Overall	1.16 ± 0.64	

p-value of ≤ 0.05 is significant and shown with asterisk*,§-Kruskal Wallis test was applied to see the significance, Units used: ml- milliliters for volume, N=Total number of study participants.

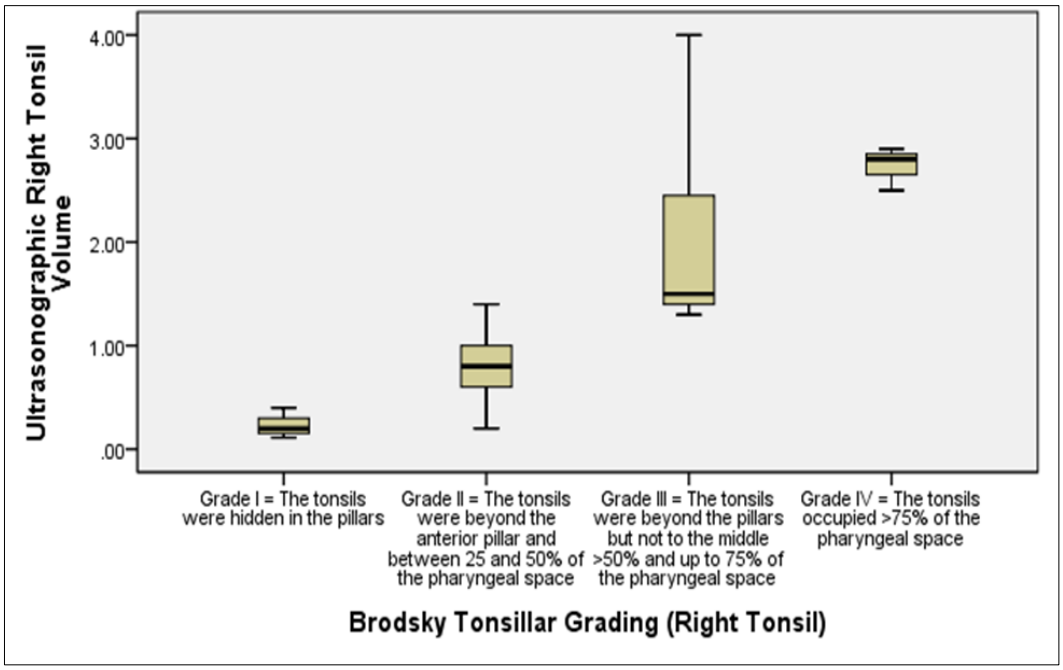


Figure 39: Box plot between right USG tonsil volume and Brodsky grading

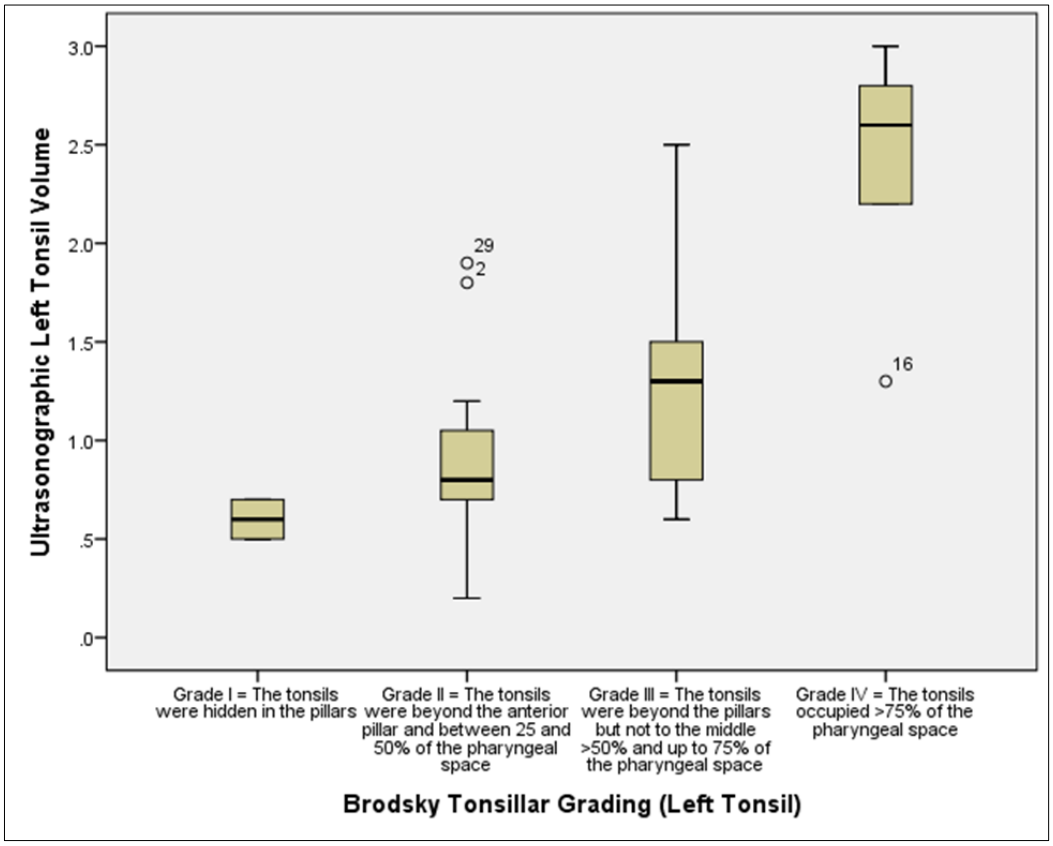


Figure 40: Box plot between left USG tonsil volume and Brodsky grading

Table 4

Association of Brodsky Tonsillar Grading With Age

N=54

Brodsky Tonsillar Grading Right Tonsil	**Mean age ± SD**	**p-value**
Grade I:Tonsils hidden within the pillars	29.67 ± 10.0	
Grade II: Tonsils were beyond the anterior pillar and between 25 to 50 % of the pharyngeal space	22.84 ± 5.3	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied >50 % and up to 75 % of the pharyngeal space	29.38 ± 9.7	0.009*§
Grade IV: Tonsils occupied >75 % of the pharyngeal space	33.0 ± 7.9	
Brodsky Tonsillar Grading Left Tonsil	**Mean age ± SD**	**p-value**
Grade I: Tonsils hidden within the pillars	16.0 ± 1.4	
Grade II: Tonsils were beyond the anterior pillar and between 25 to 50 % of the pharyngeal space	25.21 ± 7.6	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied > 50 % and up to 75 % of the pharyngeal space	26.67 ± 9.2	0.25 §
Grade IV: Tonsils occupied > 75 % of the pharyngeal space	28.5 ± 1.6	

p-value of ≤ 0.05 is considered significant and shown with asterisk*, §-One way ANOVA was applied to see the significance, Unit used-Age in years, N=Total number of study participants

Table 5

Association of Brodsky Tonsillar Grading With Gender

N=54

Brodsky Tonsillar Grading Right Tonsil	**Female (n=25)**	**Male (n=29)**	**p-value**
Grade I: Tonsils hidden within the pillars	0	3	0.079 §
	0 %	10.3 %	
Grade II: Tonsils were beyond the anterior pillar and between 25 to50% of the pharyngeal space	13	19	
	52 %	65.5 %	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied > 50 % and up to 75 % of the pharyngeal space	11	5	
	44 %	17.2 %	
Grade IV: Tonsils occupied >75 % of the pharyngeal space	1	2	
	4 %	6.9 %	
Brodsky Tonsillar Grading Left Tonsil	**Female (n=25)**	**Male (n=29)**	**p-value**
Grade I: Tonsils were hidden within the pillars	2	0	0.343 §
	8 %	0 %	
Grade II: Tonsils were beyond the anterior pillar and between 25 to 50 % of the pharyngeal space	12	16	
	48 %	55.2 %	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied > 50 % and up to 75 % of the pharyngeal space	7	11	
	28 %	37.9%	
Grade IV: Tonsils occupied > 75 % of the pharyngeal space	4	2	
	16 %	6.9%	

p-value of ≤ 0.05 is considered significant, §-Fischer Exact test was applied to see the significance, N=Total number of study participants

Table 6

Association of Brodsky Tonsillar Grading With Weight

N=54

Brodsky Tonsillar Grading Right Tonsil	**Mean Weight ± SD**	**p-value**
Grade I: Tonsils were hidden within the pillars	64.0 ± 6.5	0.017*§
Grade II: Tonsils were beyond the anterior pillar and between 25 to 50 % of the pharyngeal space	63.12 ± 10.7	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied >50 % and up to 75 % of the pharyngeal space	78.78 ± 25.7	
Grade IV: Tonsils occupied >75 % of the pharyngeal space	80.0 ± 7.2	
Brodsky Tonsillar Grading Left Tonsil	**Mean Weight ± SD**	**p-value**
Grade I: Tonsils hidden within the pillars	45.0 ± 0	0.085§
Grade II: Tonsils were beyond the anterior pillar and between 25 to 50 % of the pharyngeal space	66.69 ± 17.4	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied > 50 % and up to 75 % of the pharyngeal space	70.88 ± 18.0	
Grade IV: Tonsils occupied >75 % of the pharyngeal space	79.83 ± 14.2	

p-value of $\leq$ 0.05 is significant and shown with asterisk*, §-One way ANOVA was applied to see the significance, Units used: weight in kilograms (kg), N= Total number of study participants, SD=Standard deviation

Table 7

Association of Brodsky Tonsillar Grading Scale with BMI

N=54

Brodsky Tonsillar Grading Right Tonsil	**BMI**			**p-value**
	Normal	**Overweight**	**Obesity**	
Grade I:Tonsils were hidden in the pillars	2	1	0	0.014*§
	6.5 %	7.1 %	0 %	
Grade II: Tonsils were beyond the anterior pillar and between 25 to 50 % of the pharyngeal space	23	7	2	
	74.2 %	50 %	22.2 %	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied >50 % and up to 75 % of the pharyngeal space	6	4	6	
	19.4 %	28.6 %	66.7 %	
Grade IV: Tonsils occupied >75 % of the pharyngeal space	0	2	1	
	0 %	14.3 %	11.1%	
Total	31	14	9	
	100 %	100 %	100 %	
Brodsky Tonsillar Grading Left Tonsil	**BMI**			**p-value**
	Normal	**Overweight**	**Obesity**	
Grade I: Tonsils were hidden within the pillars	2	0	0	0.216§
	6.5 %	0 %	0 %	
Grade II: Tonsils were beyond the anterior pillar and between 25 to 50% of the pharyngeal space	18	6	4	
	58.1 %	42.9 %	44.4 %	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied > 50 % and up to 75 % of the pharyngeal space	10	6	2	
	32.3 %	42.9 %	22.2 %	
Grade IV: Tonsils occupied >75 % of the pharyngeal space	1	2	3	
	3.2 %	14.3 %	33. 3%	
Total	31	14	9	
	100 %	100 %	100 %	

p-value of ≤ 0.05 is significant and shown with asterisk*, §-Fischer Exact test was applied to see the significance, Units used: BMI = body weight in kilograms/height in meters square. Normal BMI, 18.5-24.9; overweight, 25-29.9; and obesity, 30-34.9, N=Total number of study participants

Table 8

Association of Brodsky Tonsillar Grading With Neck Circumference

N=54

Brodsky tonsillar grading (Right)	**Mean Neck circumference ± SD**	**p-value**
Grade I: The tonsils were hidden in the pillars	34.00 ± 2.79	0.002*§
Grade II: The tonsils were beyond the anterior pillar and between 25 to 50% of the pharyngeal space	33.53 ± 2.69	
Grade III: The tonsils were beyond the pillars but not to the middle >50 % and up to 75 % of the pharyngeal space	35.71 ± 3.83	
Grade IV: The tonsils occupied >75 % of the pharyngeal space	40.57 ± 2.06	
Total	34.59 ± 3.45	
Brodsky tonsillar grading (Left)	**Mean Neck circumference ± SD**	**p-value**
Grade I: The tonsils were hidden in the pillars	32.30 ± 0.00	0.014*§
Grade II: The tonsils were beyond the anterior pillar and between 25 to 50% of the pharyngeal space	33.83 ± 3.39	
Grade III : The tonsils were beyond the pillars but not to the middle > 50 % and up to 75 % of the pharyngeal space	34.72 ± 2.92	
Grade IV: The tonsils occupied >75 % of the pharyngeal space	38.53 ± 3.36	
Total	34.59 ± 3.45	

p-value of ≤0.05 is significant and shown with asterisk*, One Way ANOVA was applied to see the significance, Units used: centimeter (cm) for measurement of neck circumference, N=Total number of study participants

Table 9

Association of Brodsky Tonsillar Grading With Nasal Obstruction

N=54

Brodsky Tonsillar Grading Right Tonsil	**Nasal Obstruction**			**p-value**
	Mild	**Moderate**	**Severe**	
Grade I: Tonsils were hidden within the pillars	1	2	0	0.077§
	4.8 %	7.4%	0 %	
Grade II: Tonsils were beyond the anterior pillar and between 25 to 50% of the pharyngeal space	16	15	1	
	76.2 %	55.6%	16.7%	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied >50 % and up to 75 % of the pharyngeal space	3	9	4	
	14.3 %	33.3%	66.7 %	
Grade IV: Tonsils occupied >75 % of the pharyngeal space	1	1	1	
	4.8 %	3.7 %	16.7%	
Total	21	27	6	
	100 %	100 %	100 %	
Brodsky Tonsillar Grading Left Tonsil	**Nasal Obstruction**			**p-value**
	Mild	**Moderate**	**Severe**	
Grade I: Tonsils were hidden within the pillars	2	0	0	0.024*§
	9.5%	0 %	0 %	
Grade II: Tonsils were beyond the anterior pillar and between 25 to 50 % of the pharyngeal space	13	14	1	
	61.9 %	51.9%	16.7%	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied >50% and up to 75% of the pharyngeal space	6	10	2	
	28.6 %	37.0 %	33.3 %	
Grade IV: Tonsils occupied >75 % of the pharyngeal space	0	3	3	
	0.0 %	11.1%	50 %	
Total	21	27	6	
	100 %	100 %	100 %	

p-value of ≤ 0.05 is significant and shown with asterisk*, §-Fischer Exact test was applied to see the significance, VAS (Visual Analog Scale) for nasal obstruction (mild 0-2, moderate 3-7 and severe 8-10), N=Total number of study participants

Table 10

Association of Brodsky Tonsillar Grading with ESS

N=54

Brodsky Tonsillar Grading Right Tonsil	**ESS**		**p-value**
	≤ 10	**Above 10**	
Grade I : Tonsils were hidden within the pillars	3 7.9 %	0 0 %	0.0001*§
Grade II : Tonsils were beyond the anterior pillar and between 25 to50 % of the pharyngeal space	30 78.9 %	2 12.5 %	
Grade III : Tonsils were beyond the pillars but not to the middle and occupied >50 % and up to 75% of the pharyngeal space	5 13.2 %	11 68.8 %	
Grade IV: Tonsils occupied >75 % of the pharyngeal space	0 0 %	3 18.8 %	
Total	38 100 %	16 100 %	
Brodsky Tonsillar Grading Left Tonsil	**ESS**		**p-value**
	≤ 10	**Above 10**	
Grade I :Tonsils were hidden within the pillars	2 5.3 %	0 0.0 %	0.144 §
Grade II: Tonsils were beyond the anterior pillar and between 25 to 50 % of the pharyngeal space	22 57.9 %	6 37.5 %	
Grade III: Tonsils were beyond the pillars but not to the middle and occupied >50 % and up to 75 % of the pharyngeal space	12 31.6 %	6 37.5 %	
Grade IV: Tonsils occupied >75 % of the pharyngeal space	2 5.3 %	4 25.0 %	
Total	38 100 %	16 100 %	

,

p-value of ≤0.05 is significant and shown with asterisk*, -Fischer Exact test was applied to see the significance, ESS Score: ≤10 indicates normal, above 10, and up to 24 indicates excessive day time sleepiness or sleep disorder, N=Total number of study participants

Table 11

Association of MS with Nasal Obstruction

N=54

MS	Nasal Obstruction			p-value
	Mild	Moderate	Severe	
Grade I: Tonsils, pillars and soft palate are clearly visible	14 66.7 %	12 44.4 %	1 16.7 %	0.006*§
Grade II : Uvula, pillars and upper pole are visible	6 28.6 %	13 48.1 %	1 16.7 %	
Grade III: Soft palate is partly visible; while the tonsils, pillars and base of uvula are all invisible	1 4.8 %	2 7.4 %	4 66.7 %	
Grade IV: Only hard palate is visible	0 0 %	0 0 %	0 0 %	
Total	21 100 %	27 100 %	6 100 %	

p-value of ≤ 0.05 is significant and shown with asterisk*, §-Fischer Exact test was applied to see the significance, VAS for nasal obstruction (mild 0-2, moderate 3- 7 and severe 8-10)

N=Total number of study participants

Table 12

Association of MS with BMI

N=54

MS	BMI			p-value
	Normal	**Overweight**	**Obesity**	
Grade I: Tonsils, pillars and soft palate are clearly visible	19 61.3 %	7 50.0 %	1 11.1 %	0.003*§
Grade II: Uvula, pillars and upper pole are visible	11 35.5 %	6 42.9 %	3 33.3 %	
Grade III :Soft palate is partly visible; while the tonsils, pillars and base of uvula are all invisible	1 3.2 %	1 7.1 %	5 55.6 %	
Grade IV: Only hard palate is visible	0 0 %	0 0 %	0 0 %	
Total	31 100 %	14 100 %	9 100 %	

p-value of ≤ 0.05 is significant and shown with asterisk*, §-Fischer Exact test was applied to see the significance, Normal BMI: 18.5-24.9; overweight, 25-29.9; and obesity, 30-34.9

N=Total number of study participants

Table 13

Association of MS with ESS

N=54

MS	ESS		p-value
	≤ 10	**Above 10**	
Grade I: Tonsils, pillars and soft palate are clearly visible	23 60.5 %	4 25.0 %	0.013*§
Grade II: Uvula, pillars and upper pole are visible	13 34.2 %	7 43.8 %	
Grade III :Soft palate is partly visible; while the tonsils, pillars and base of uvula are all invisible	2 5.3 %	5 31.3 %	
Grade IV: Only hard palate is visible	0 0 %	0 0 %	
Total	38 100 %	16 100 %	

p-value of ≤ 0.05 is significant and shown with asterisk*, §-Chi-square test was applied to see the significance, ESS Score: ≤ 10 indicates normal, above 10, and up to 24 indicates excessive day time sleepiness or sleep disorder, N=Total number of study participants

Table 14

Association of BMI with Snoring

N=54

BMI	Snoring		Total	p-value
	No	**Yes**		
Normal	24 80 %	7 29.2 %	31 57.4%	0.001*§
Overweight	4 13.3 %	10 41.7 %	14 25.9 %	
Obese	2 6.7 %	7 29.2 %	9 16.7 %	
Total	30	24	54	
	100 %	100 %	100 %	

p-value of ≤0.05 is significant and shown with asterisk*, §-Fischer Exact test was applied to see the significance, Normal BMI, 18.5-24.9; overweight, 25-29.9; and obesity, 30-34.9.

N=Total number of study participants

Table 15.1

Association of BMI with Neck Circumference (Male)

N=29

BMI	Neck circumference male		Total	p-value
	> 42 cm	**≤42 cm**		
Normal	0 0%	20 71.4 %	20 69 %	0.310 §
Overweight	1 100 %	7 25.0 %	8 27.6 %	
Obese	0 0 %	1 3.6 %	1 3.4 %	
Total	1 100 %	28 100 %	29 100 %	

p-value of ≤ 0.05 is significant and shown with asterisk*, §-Fischer Exact test was applied to see the significance, Collar size should not exceed 42cm in males and 37.5cm in females

Normal BMI, 18.5-24.9; overweight, 25-29.9; and obesity, 30-34.9, N=Total number of male participants

Table 15.2

Association of BMI with Neck Circumference (Female)

N=25

BMI	Neck circumference Female		Total	p-value
	> 37.5 cm	**≤ 37.5 cm**	**Total**	**p-value**
Normal	0 0.0 %	11 64.7 %	11 44.0 %	0.0001 * §
Overweight	1 12.5 %	5 29.4 %	6 24.0 %	
Obese	7 87.5 %	1 5.9 %	8 32.0 %	
Total	8 100 %	17 100 %	25 100 %	

p-value of ≤0.05 is significant and shown with asterisk*, §-Fischer Exact test was applied to see the significance, Collar size should not exceed 42cm in males and 37.5cm in females

Normal BMI, 18.5-24.9; overweight, 25-29.9; and obesity, 30-34.9, N=Total number of female participants

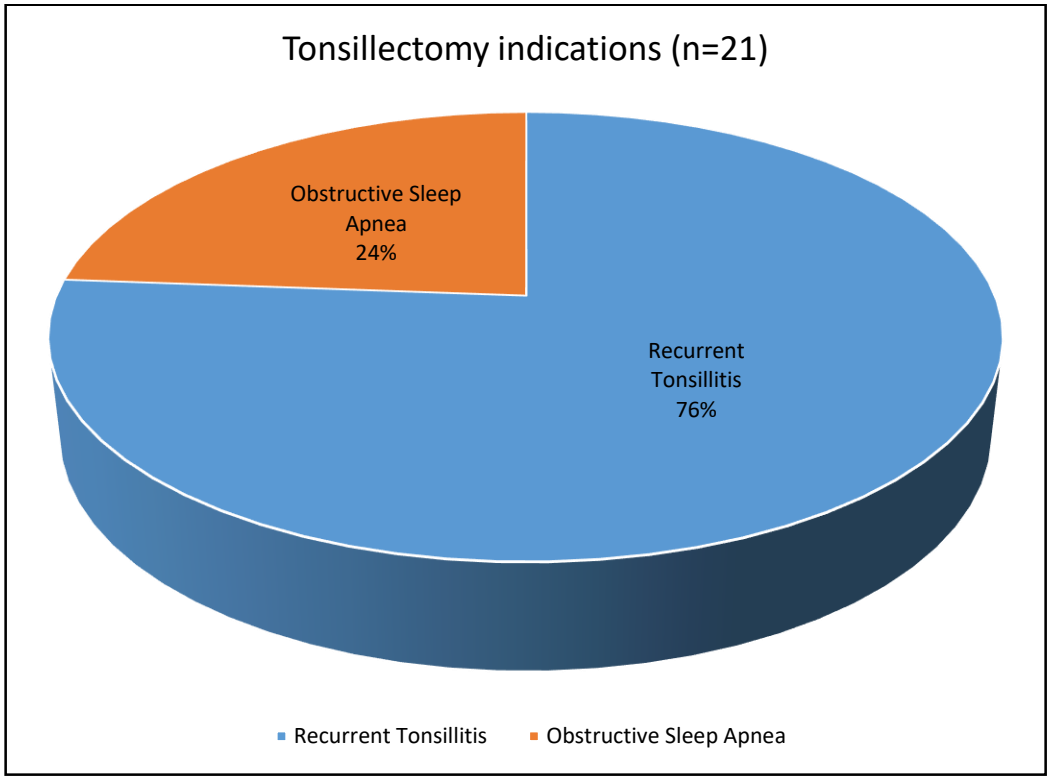


Figure 41: Pie chart showing indications of tonsillectomy in present study

Table 16

Association of Age, Gender and Neck Circumference with USG Tonsil Volume

Variables		Mean USG volume ± Standard Deviation	p-value
Age Group			
Right Tonsil	≤ 35 years	1.17 ± 0.88	0.295 §
	> 35 years	1.55 ± 0.89	
Left Tonsil	≤ 35 years	1.16 ± 0.63	0.794 §
	> 35 years	1.22 ± 0.71	
Gender			
Right Tonsil	Female	1.52 ± 0.9	0.019 *§
	Male	0.96 ± 0.7	
Left Tonsil	Female	1.33 ± 0.7	0.082 §
	Male	1.02 ± 0.52	
Neck Circumference Female			
Right Tonsil	> 37.5 cm	1.96 ± 0.99	0.138 §
	≤ 37.5 cm	1.32 ± 0.96	
Left Tonsil	> 37.5 cm	1.86 ± 0.84	0.01 *§
Neck Circumference – Male			
Right Tonsil	> 42 cm	2.9 ± 0.0	0.003 *§
	≤ 42 cm	0.89 ± 0.6	
Left Tonsil	> 42 cm	2.8 ± 0.0	0.0001 *§
	≤42 cm	0.96 ± 0.4	

p-value of ≤ 0.05 is significant and shown with asterisk*, §-Independent sample t-test was applied to see the significance, Units used: Age in years, neck circumference in cm

Table 17

Association of USG Volume with BMI

N=54

BMI		Mean USG Volume ± Standard Deviation	p-value
Right Tonsil	**Normal**	0.95 ± 0.77	0.018*§
	Overweight	1.50 ± 0.93	
	Obese	1.77 ± 0.94	
	Total	1.23 ± 0.89	
Left Tonsil	**Normal**	0.92 ± 0.38	0.002*§
	Overweight	1.43 ± 0.81	
	Obese	1.61 ± 0.76	
	Total	1.17 ± 0.64	

p-value of ≤ 0.05 is significant and shown with asterisk*, §-One Way ANOVA was applied to see the significance, Units used: BMI = body weight in kilograms/height in meters square.

Normal BMI, 18.5-24.9; overweight, 25-29.9; and obesity, 30-34.9, N=Total number of study participants

Table 18

Association of USG volume with ESS

N=54

ESS		Mean USG volume ± Standard Deviation	p-value
Right Tonsil	< 10 Normal	0.90 ± 0.68	0.001*€
	Above 10 (out of 24)	1.99 ± 0.85	
Left Tonsil	< 10 Normal	0.95 ± 0.43	0.001*€
	Above 10 (out of 24)	1.66 ± 0.77	

p-value of ≤0.05 is significant and shown with asterisk*, €-Independent sample t-test was applied to see the significance, ESS Score: ≤10 indicates normal, above 10, and up to 24 indicates excessive day time sleepiness or sleep disorder, N=Total number of study participants

Table 19

Association of MS with USG Tonsillar Volume

N=54

Mallampati Scoring	**Mean USG volume of Right Tonsil ± SD**	**p-value**
Grade I: Tonsils, pillars, and soft palate are clearly visible	0.88 ± 0.5	0.009*€
Grade II: Uvula, pillars, and upper pole are visible	1.48 ± 1.0	
Grade III: Soft palate is partly visible; while the tonsils, pillars, and base of uvula are all invisible	1.81 ± 1.1	
Grade IV: Hard palate only is visible	0 ± 0.0	
Overall	**1.22 ± 0.88**	
Mallampati Scoring	**Mean USG volume Left Tonsil ± SD**	**p-value**
Grade I: Tonsils, pillars, and soft palate are clearly visible	0.90 ± 0.4	0.001*€
Grade II: Uvula, pillars, and upper pole are visible	1.29 ± 0.6	
Grade III: Soft palate is partly visible; while the tonsils, pillars, and base of uvula are all invisible	1.66 ± 0.3	
Grade IV: Hard palate only is visible	0 ± 0.0	
Overall	**1.16 ± 0.64**	

p-value of ≤0.05 is significant and shown with asterisk*, €-Kruskal Wallis test was applied to see the significance, SD: Standard Deviation, N=Total study participants

CHAPTER 5

DISCUSSION

The present study "Morphological and ultrasonographic association of tonsil grading with objective tonsil size in adults" determines the size (volume) of palatine tonsil through USG and gives association of it with Brodsky tonsillar grading and relates the measurements of present study with previous studies to find the difference between the results.

Use of the clinical, structural and morphological parameters which were chosen for the research, the advancement of the disease like OSA can be recognized and the treatment option for the patient may be transformed, so the knowledge can be utilized as prognostic reference to classify the disease. This formative study had discovered that patients with hypertrophic tonsils can have an ultrasonographic assessment of its size in order to avoid wrong subjective estimation.

Clinical assessment of tonsil was done in the present study using Brodsky tonsillar grading which is easily performed and clinically practical. A Chinese Prospective study evaluated three tonsil grading scales. These include Brodsky grading scale, 3–grade scale and 5-grade scale and demonstrated that Brodsky tonsillar grading produced better intraobserver and inter observer reproducibility. A modified 3-grade scale has extensive grade interval and therefore can have greater chances of error because of repeated measurements. To provide an actual elucidation is difficult, as we wonder that our eyes detect halves and quarters more easily than thirds (Ng, Lee, Li, Wing & Tong, 2010).

In the present study, other subjective scoring system were not assessed, rather comparison of clinical grading with ultrasonographic size was performed. Predictive strength of Brodsky scoring system can be limited due to disagreement with objective measurements and polysomnography measurements. Pharyngeal airway is a three dimensional structure and

assessment of tonsil in all dimensional approach is needed. Moreover anteroposterior, superior inferior dimensions and endophytic tonsils should also be measured. A modified and comprehensive evaluation tool is needed for pre surgical assessment of patient with recurrent tonsillitis and OSA. That is why in the current study high frequency ultrasound technique was utilized for initial evaluation of tonsil size. Later on other parameters like elastography, perfusion of tissue, dynamic account of obstructive sites more importantly at oropharyngeal and tonsil levels and for how much duration these structures causing occlusion during arousal and sleep states can be studied through this technique.

This study was conducted to evaluate the possibility of ultrasonography to measure tonsil volume as this method is painless, non -invasive and has high patient compliance. Many previous studies reported its usage in diagnosis of tonsillar pathologies but these pioneer studies were conducted on pediatric population (Fordham et al., 2015; Hosokawa et al., 2017). Another seminal study performed by Bandarkar et al., (2016) testified usage of this novel technique and discussed its addition to routine procedures exclusively in peritonsillar abscess.

The present study explored the success of USG in adults and saw a significant association between Brodsky tonsillar grading and ultrasonographic volume which concords with study by Asimakopoulos et al ., (2017) performed on children and by Mengi, Sagtaş & Kara (2020) which included children and adults, showed stronger association in children as compare to adults. Presence of excessive sub cutaneous fat in adults could affect measurement results. Therefore, this technique can be utilized in all age groups.

A study by Howard and Brietzke (2009) also reported a significant association between clinical grading and ultrasonographic volume. Wang et al., (2010) reported tonsillar dimensions along with its volume correlates significantly with subjective assessment in OSA patients involving both pediatric and adult population while there was discordance found in statistical significance between total volume and subjective size of tonsil in pediatric population. Cahali et al., (2011) highlighted similar results that is significant correlation between grading of tonsil and objective volume of tonsil but all these researches considered tonsillar subjective grading and did not determine asymmetric tonsils, which are found in routine practice.

The main focus of the present study revolved around adult patients with hypertrophic tonsils, and documented right and left tonsils of each study participant individually. Thirty one out of 54 participants (57 %) had asymmetric tonsils. Similarly tonsillar asymmetry was found by Lai et al., (2014) which was 17 out of 51 study participants (33 %).

As already described before, narrow pharyngeal cavity has critical impact on pathophysiology of pharyngeal diseases such as OSA, tonsillectomy is regarded as an effective treatment to enlarge pharyngeal cavity. Preoperative assessment of tonsil size can be an essential parameter for tonsillectomy as stated by Davoodreza, (2011). Therefore the current research determined the size through clinical grading and USG preoperatively.

In many preceding studies based on USG of tonsils, clinical tonsillar classification was not used, yet the current study identified a correlation between Brodsky tonsillar grading and ultrasonographic volume. Lai et al., (2014) in their study reported that objective estimation of tonsil size was a better predictor of the seriousness the disease like OSA than subjective grading of tonsil in adults. Further in case of endophytic tonsil the size on clinical examination may be false, these patients with lower clinical grading may be found during tonsillectomy to have much greater expansion than predicted. In these circumstances USG is a considerable addition that provides direction on clinical follow up or management decisions.

In the present study association of age and gender with USG volume was obtained which was not significant and shows no relation in adults. Similarly, volume assessment through subjective grading also has no effect on age. Mengi, Sagtaş, & Kara (2020) in their study showed that both subjective and USG volumes had no effect in adults but tonsillar volume increases in children with age. Effect of BMI which was considered in their study showed no impact on tonsil volume in children and adults which concords with the present study findings with respect subjective grading but USG volume showed strong association when compared with BMI. In another study by Ozturk et al., (2018) which is also USG study, demonstrated a significant correlation of age and BMI with tonsil volume. Correspondingly Wang et al., (2010) described a greater objective tonsil volume in obese pediatric group as compared to control group which concords with present study findings but the age group comprises of adult individuals in the current study.

Kaditis et al., (2019) estimated association of clinical grading in subjects with or without sleep disordered breathing. Non-significant difference was found between subjective tonsil sizes, age or obesity. Such controversy between the results can be due to either measurement or patient selection methods. Conversely, Hong, Lee & Jeong (2018) in their research showed that tonsil volume augments with age but not with height or weight. Therefore, more exploration is required to study the effect of obesity on volume of tonsil and USG can be utilized for this reason.

Prim, De Diego, García-Bermúdez, Pérez-Fernández & Hardisson, (2010) reported that there is an association of palatine tonsil volume with epidemiological parameters. Crombie & Barr (1990) determined that palatine tonsil volume was associated directly with age, height and weight and inversely related to the duration of recurrent tonsillitis. Conversely a low correlation between clinical size of pediatric tonsil and objective size as well as severity of OSA was studied by Nolan & Brietzke, (2011). Sagıroglu, (2017) found a significant correlation between right and left tonsillar volume with age, length, width and depth of the tissue. Another study by Kang, Chou, Weng, Lee & Hsu (2013) reported correlation of age, obesity and hypertrophic tonsil with OSA. Yasan et al., (2011) reported significant correlation between subjective and objective tonsil size, age, BMI, body surface area and inverse relation between objective tonsillar volume and distance between anterior pillars. The routine assessment of tonsil volume in clinical practice is not practical (Prim et al., 2010). Sagıroglu, (2017) suggested that use of different techniques can provide real evaluation of tonsillar volume. Therefore, in the present study ultrasonographic technique was utilized which is more feasible in clinical practice.

In the present study no association of gender with clinical grading of tonsils was found but the study sample comprised of more male participants. Further this study explored higher grades III (19 tonsils) and IV (5 tonsils) to be present in females more as compared to male that is grade III (16 tonsils) and IV (4 tonsils). Whereas grade II tonsil was found more in males (35 tonsils) as compared to females (25 tonsils). Contradictory results were found in a study by Rodrigues, Dibbern & Goulart (2010) in which they have shown statistically significant relation of male gender with increasing tonsillar grades causing obstructive sleep disorder. Similarly, this finding was observed in large population based studies conducted by

Stradling, & Crosby (1991) in United States and Europe. A Brazilian study by Tufik, Santos-Silva, Taddei, & Bittencourt (2010) showed association of male gender with OSA.

Hypertrophic tonsil and recurrent tonsillitis can cause difficulty in swallowing, OSA and body growth disturbance. Still, the relationship between BMI and hypertrophic tonsil is controversial. The present study got significant relationship of BMI with ultrasonographic size, whereas in terms of subjective grading, right tonsil showed significant results and the left showed non-significant relationship with BMI. There are many studies in literature that compared tonsillar hypertrophy with BMI in pediatric age group but there are very few studies conducted in adults. Lai et al., (2014) reported that BMI does not reflect size of tonsil in adults. A study was conducted by BK, Yogeesha & Asha (2017), in which they reported non-significant correlation of clinical grading with BMI. Therefore more studies are required to resolve this controversy.

Neck circumference is an important anthropometric tool to assess overweight/obese individuals as it is easy, cost effective and culturally acceptable. Much have been investigated regarding obesity which is a foremost health issue in the present era, creating negative social and emotional disturbances along with high risk of chronic deadly conditions like cardiovascular disease, diabetes mellitus, hypertension and decreased life span. Tantawy, Kamel, Alsayed, Rajab, & Abdelbasset, (2020). In order to detect overweight individuals there have been many parameters discovered, out of which BMI assessment is significant. The current study also evaluated relationship of BMI with neck circumference. Over all non-significant relationship was found between neck circumference and BMI but regarding gender highly significant association was found in females and non-significant for males. Ma, Wang, Liu, Lu, Liu, & Yin (2017) in their systemic review concluded that neck circumference has a moderate precision for detection of obese individuals. Concomitantly Morais et al., (2018) in their article reported they were unable to established definitive cut off values for neck circumference due to various measurement site, gender and age differences. However, Alzeidan, Fayed, Hersi & Elmorshedy (2019) demonstrated a positive correlation of neck circumference with BMI and waist circumference and concluded that neck circumference can be used to screen individuals with obesity. Likewise Alfadhli et al., (2017) showed significant association of neck circumference with BMI. Tantawy et al.,

(2020) revealed weak correlation of neck circumference with BMI. These associations are meaningful but these studies were in adolescent population and not true representative of adult age group. In an observational study conducted by Ben-Noun, Sohar & Laor, (2001) comprising of adult subjects revealed highly significant association of neck circumference with age and other anthropometric measurements like age, weight, height, waist and hip circumference. Similar statistically significant associations were revealed by a Pakistani research conducted in young adults (Hingorjo, Qureshi & Mehdi 2012). A Turkish cross sectional study by Onat et al., (2009) had significant relationship between neck circumference and BMI. Further similar associations were found in elderly population of China by Yang et al., (2010) and later on by Yan et al., (2014). A Spanish cross sectional study publicized in their research article that neck circumference associated with anthropometric measurements such as BMI and waist circumference but all together it cannot predict central adiposity or total body fat composition as predicted by BMI and waist circumference in adult population (Téllez et al., 2020). Therefore neck circumference can only be utilized as an additional screening tool along with other more sensitive anthropometric measurements.

This prospective study has demonstrated use of anthropometric measurements in clinical settings like, height, weight and neck circumference in context to tonsillar enlargement. This is in observance with literature that OSA associated with higher BMI is of complex etiology. It may be associated with lymphoid hyperplasia, neuro motor aspects affecting collapsibility of upper airway, or increased fat deposition around the neck (Narang et al., 2018). Schwab et al., (2015) investigated in their MRI based study regarding significance of hypertrophic tonsils in disease process of OSA in young obese subjects. The main focus of the present study revolved around morphological parameters associated with hypertrophic tonsils and its associated manifestations, and the current study's results are in agreement with these studies in providing convenient tool to screen obese adult population.

The present study's results remained steady in procuring statistically significant results for relationship between clinical grading of tonsil and neck circumference. Narang et al., (2018) reported hypertrophic tonsils and anthropometric measurements like neck circumference and height measurements may have predictive ability for OSA and these parameters can be

utilized in ambulatory settings in order to screen high risk obese young population. Likewise, Ho, Moul, Krishna (2016) showed in their retrospective study that neck circumference was significantly linked with OSA presence, but their research differed from us in that they have wider range of BMI and age in their study participants with or without obstructive sleep disorder and the study design was not prospective.

Findings of the present study contradicts with results of BK, Yogeesha & Asha (2017) in which they reported non-significant correlation between clinical grading and neck circumference in adults, and proposes that these predictive factors might be of significance in OSA subjects in contrast with patients with recurrent tonsillitis. Moreover, this prospective study revealed significant association of USG volume of tonsil with neck circumference which was not found in literature.

ESS has been commonly utilized as a predictor of OSA however with changeable outcomes. The current study compared subjective and USG measurements with ESS and found highly significant correlation with USG volume whereas very low association with subjective grading was found. The current study results are in agreement with Cahali et al., (2011) in which they reported positive correlation of tonsil volume and ESS, and Lai et al., (2014) in which researchers explored strong positive association of objective tonsil volume and ESS whereas borderline association of subjective grading of tonsil. Therefore the present study suggests that objective assessment of tonsil have more predictive strength to identify OSA severity than subjective grading.

Tonsil size is not only the factor, there are other parameters that needed to be considered when diagnosing or assessing OSA patient. These include age, gender, BMI, neck circumference, American Society of Anesthesiologists (ASA) score, Mallampati score and comorbidities including hypertension and diabetes (Singla, Gattu, Aggarwal, Bhambri, & Agarwal, 2019).

Questionnaires like ESS and Berlin have been developed to detect suspected OSA patients, emergency screening and paranesthesia evaluation of a patient requiring emergency intervention. Sensitivity of ESS reported to be 93.4. % by Lee, Kang & Lee (2012). Higher tongue grading was seen in patients with OSA during physical examination. Barceló, Mirapeix, Bugés, Cobos & Domingo (2011) proposed in their study independent usage of

tongue grading for risk assessment of OSA. Myers, Mrkobrada & Simel (2013) explored (9.3) positive predictive strength of MS in their research. Further Rodrigues et al., (2010) found a positive association of this scoring with nasal obstruction and OSA.

A recent Pakistani study was conducted to investigate an economical and effective approach for the diagnosis of obstructive airway disease. Hassan, Altaf & Haider (2019) established significant association of higher Mallampati grade with higher ESS scores, consequently greater risk of OSA in patients with higher tongue grading. Similarly the present study explored significant association of MS with ESS.

Contrary to the current study Bins et al., (2011) demonstrated non-significant association between above mentioned parameters and cannot be used for prediction of OSA. Many studies in the literature were found to contradict with the results of the present study and above mentioned studies. These include study by Naqvi et al., (2018) in which they reported Berlin and ESS questionnaire had non-significant association with higher tongue grading. However MS system have predictive strength to identify OSA in low risk individuals of ESS and Berlin scoring system. In their study significant relationship of MS was observed with snoring and non-significant association was found with BMI. This prospective study contradicts with a study by Nuckton, Glidden, Browner & Claman, (2006) in which authors of the research declare MS as a part of physical examination before polysomnography further affirams it as an independent marker of presence and severity of OSA and reported its relationship with ESS as non-significant. Unadjusted associations of Mallampati has been reported by Friedman et al., (1999) and Zonato, Bittencourt, Martinho, Junior, Gregório & Tufik, (2003) which is more indicative of occlusion of airway caused by tongue during sleep. Similarly contrary result was reported by Gonzales, Marshall, & Russian, (2011) in which they have found insignificant association between two scoring systems.

In a Pakistani research Naqvi et al., (2018) reported increase prevalence of OSA has been linked with increasing obesity. Liistro, Rombaux, Belge, Dury, Aubert & Rodenstein, (2003) showed statistically significant association of increase BMI with higher tongue grading with p-value 0.01. Similarly the present study demonstrated significant association of increased MS with higher BMI. Concurrent results was found by Duarte et al., (2016) with significant correlation between BMI and MS. A CT-scan based study which includes 81 male patients

revealed positive association of higher MS with BMI, age and tongue volume (De Athayde, Schorr, Gebrim, Lorenzi-Filho & Genta 2017). Wang, Sun & Huang (2018) in their meta-analysis based on relation of obesity with challenging intubation demonstrated significant association of BMI with higher MS in adult patients.

Opposing results was reported by Naqvi et al., (2018) in which 20 % of study participants were with normal BMI with tongue grade 3 and 4 whereas 22.3 % were overweight and obese with non-significant association between MS and BMI.

Assessment of upper airway especially the nasal cavity during physical examination is extremely important with suspension of OSA. Increase in apnea during sleep is associated with nasal obstruction because of raised negative pressure with in airway during inspiratory cycle. Similarly assessment of tongue grading is also important and has influence on sleep disordered breathing. Individuals with higher scores of Mallampati have an increased tendency of obstruction due to macroglossia impeding airway from nasal and oral cavity to lower respiratory tract (Rodrigues, et al., 2010).

Liistro et al., (2003) demonstrated highly significant association of high MS with nasal obstruction, simple nasal patency test was used to test nasal permeability in 202 study participants and tongue grading was done by modified MS. These authors concluded that above mentioned clinical parameters must be considered in suspected OSA patients. Moreover their strong association involves consideration of sleep specialist and anesthetist. Correspondingly same results were observed in the present study but nasal obstruction was assessed via rough and approximate method of Visual Analog Scale which rapidly directs whether a patient had patent nasal passage or not.

Likelihood of an individual evolving apnea and its subsequent deterioration associated with increasing MS and nasal obstruction such individuals have two occlusion points aggravating sleep apnea because now the patient undergoing greater chest stress and exertion in order to overcome these occlusal points. Rodrigues et al., (2010) in their study revealed that Mallampati score with high grades was an independent risk factor for development of apnea and its severity. They also exhibited association of nasal obstruction with MS in which they found a significant association which is also found in the present research. Further they found that effect of nasal obstruction does not cause supplementary risk to the worsening of apnea

in their study sample as there was no effect observed for tongue grading with apnea hypopnea index.

Friedman, Vidyasagar, Bliznikas, & Joseph (2005) discovered that Friedman scoring of subjects with higher Mallampati grade was higher with low success of uvulopharyngoplasty. Recently Hassan, Altaf & Haider (2019) discovered positive association of MS with nasal obstruction and ESS. Therefore vigilant evaluation of patients with obstructive airways, identification of obstructive anatomical sites and their surgical treatment are important. Moreover, high tongue grading is considered to be an independent risk factor whereas nasal obstruction is an added risk associated for aggravation of apnea.

On the basis of cephalometric data it is assumed that the Asian population has very inimitable craniofacial features that lead them to sleep disordered breathing in OSA patients in a comparatively lower limits of BMI. One third of Pakistani population in the form of nasal obstruction drops into this category (Sultan et al., 2019). Nasal obstruction in the present study was analyzed through visual analog scale which is a self-administered subjective scoring in which 39 % patients reported mild, 50 % moderate and 11 % severe nasal obstruction. When nasal obstruction was compared with subjective grading of tonsil statistically significant association was obtained. Therefore higher tongue grading when associated with nasal obstruction may predispose to conditions like OSA. These findings are in agreement with Liistro et al., (2003) whereas the impact of nasal resistance to OSA found by Lofaso et al., (2000) was not strong that is 2.3 % of Apnea hypopnea index variance. Another study by Nuckton et al., (2006) reported MS as a predictor of the existence and disease severity of OSA. Therefore usage of different combination assessment tools is required for the detection of OSA in adults.

Snoring is caused by turbulence of airflow in the upper airway, a vibratory sound-produced during sleep and frequently accords with inspiratory phase of respiration. Compared to other respiratory sounds snoring has specific frequency and characteristics. It is common and have many associated risk factors like obesity, obstructive nasal passage, allergies, hypertrophic tonsil, smoking and systemic associations like diabetes, hypertension and cardiovascular disease similar to OSA associations. These associations were also studied in Asian population and relation of age greater than 65-years was also found, its prevalence in young

age group (30-50 years) was also reported in many studies. Therefore this condition is not associated with local airway pathology but has systemic manifestations as well. (Wada et al., 2019). In the present study there were 44% snorers out of which 7 (29.2 %) were normal weight, 10 (41.7 %) were overweight and 7 (29.2 %) were obese.

Relationship of snoring with BMI was assessed in this study which was found to be highly significant in which most of the study participants fall into the category of overweight (BMI: 25-29.9 Kg/m^2). Similar association was found by Seren, San, Cingi, Muluk,& Durukan, (2014), but their study differs with present study in that it was conducted on pediatric population. Statistically significant association was found between BMI and snoring in a study by Wada et al., (2019) which was conducted on adults they have demonstrated significant association of BMI and snoring in women but in men significant association was found in normal weight individuals whereas in overweight and obese category this association was detectable but not reached significant level.

Evaluation of snoring is easy, based on history and assessment of airway during physical examination, it is a depiction of OSA. Much have been investigated about its association with metabolic syndrome which involves multiple metabolic disorders along with obesity, dyslipidemia, hypertension and hyperglycemia and taken to be a reason of many chronic disorders like diabetes, hypertension, cardiovascular diseases and successive disease linked mortality. In the present study 17 % study participants were found to be hypertensive, 44 % snorers, 11 % individuals with severe nasal obstruction and 17 % obese individuals. Shin et al., (2014) reported in their prospective cohort study strong association of snoring with BMI and metabolic syndrome. Similar results were found by Murguía-Romero et al., (2012) in which authors emphasize on BMI as a valuable mean to determine metabolic syndrome. Li et al., (2019) reported additive interaction of BMI and snoring in the disease process and reported significant association in metabolic syndrome; these are also risk factors for OSA. Further they declared obesity as an amendable risk factor and a serious aspect in management and prevention of disease condition.

Difficult intubation has multiple associations like obesity, high MS, increased neck circumference and other bedside parameters like thyro-mental distance (Gonzalez et al., 2008). The present study explored highly significant association of MS with BMI, neck

circumference and ESS. Brodsky et al., (2002) also reported relationship of obesity and neck circumference with difficult laryngoscopy. Therefore these parameters are needed to be assessed before patient goes for surgery. No contradictory study was found in the literature with respect to the current study results.

Tonsillectomy rate increased comparably in this study with increasing size of the tonsil that is 21 (39 %) individuals in present study underwent tonsillectomy out of which 5 (24 %) patients had obstructive pathology that is OSA and 16 (76 %) patients had infective pathology that is recurrent tonsillitis. Results of the existing study compares positively with a study done by Alkadem et al., (2018). They reported infective tonsillitis accounting for 46 % and upper airway obstruction accounting for 27 %. Hence recurrent infective tonsillitis remains the most common indication for surgery. Concurrent result were found in another study by Davoodreza, (2011) which includes children and adults along with hypertrophic tonsils. They found statistical correlation between size of tonsil and rate of its surgery and determined that size of tonsil assessed preoperatively can be an important parameter for its surgery.

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CHAPTER 6

CONCLUSION

6.1 CONCLUSION OF THE STUDY

The present study “Morphological and ultrasonographic association of tonsil grading with objective tonsil size in adults” concluded that Brodsky clinical grading for tonsil was associated significantly with ultrasonographic tonsil volume. Hence subjective grading may reveal actual tonsil volume besides certain limitation of this scoring system for grade II and III due to undervalued or overvalued estimation of tonsillar tissue, evaluation of this tissue refines the diagnosis and decisions. Quantitative assessment of tonsillar volume aids clinical assessment and can be helpful in decisions for surgery as well as for OSA patients. Therefore, USG is the novel technique in Pakistan and not being utilized for this purpose, as it is helpful and practical tool for measurement of objective tonsillar volume. There was no association of clinical grading for tonsil with age, gender, weight, BMI and ESS whereas significant association was found for neck circumference and nasal obstruction. Regarding USG volume, positive association was observed with gender, BMI, neck circumference, ESS and MS. Statistically significant association was obtained for MS with BMI, ESS and nasal obstruction. BMI was significantly associated with snoring whereas no association was found with neck circumference.

6.2 RECOMMENDATIONS

The main recommendations of the current study are:

- The parameters which were measured in the present study are helpful in assessment of risk factors for OSA patients and subjects undergoing tonsillectomy. Consequently these findings will highlight the significant of future research in terms of sleep related disorders with their anatomical involvement in Pakistani population.
- Knowledge of tonsil anatomy, physiology and vulnerability to infection helps the physician in accurate diagnosis and appropriate treatment. Quantitative assessment of tonsillar volume aids clinical assessment and can be helpful in decisions for surgery and for OSA patients.
- Future study with large sample size in order to generalized the study findings
- Inclusion of all age groups
- Multicenter study should be considered
- Comparison of clinical grading, ultrasonographic size and post tonsillectomy volume of specimen can be done, usage of other imaging modalities such as lateral X-rays and MRI
- Measure level of satisfaction of life and academic achievements after tonsillectomy
- As USG of palatine tonsil and oropharynx is not a routinely used imaging method, the experience of radiologists in this field is relatively limited. For this reason, assessment of the effect of increased experience of radiologist in the measurement of tonsil volume can be done and compliance between these ultrasonographic measurements and actual can be determined as the research progresses

6.3 STRENGTHS OF STUDY

- Use of USG in order to extend the usage of imaging techniques to assess tonsil anatomy in the Pakistan.
- Single handed, one radiologist, blinded to study hypothesis
- Reconfirmation of grading to reduce biasing
- Results of the present study prove a step towards developing a better diagnostic and grading system for hypertrophic tonsil

6.4 LIMITATIONS OF STUDY

- This pioneer study proved to be a milestone step in regards of a research conducted over tonsil morphological parameters done for the first time in Pakistan. This study had several limitations, comparison in different races and ethnicities, should have been multi-centric study, small sample size due to less duration of study.
- Children were not included as they have different growth parameters of assessment and there is variation of tonsil size during childhood
- No comparison was done with volume calculated by water displacement method
- Number of patients coming to OPD was less
- As clinical measurements were made by common consensus, no comparison was made between the operators
- USG is the safest and non-invasive method of determination of volume of tonsils, but the maximum size of tonsillar tissue may be variable due to positioning and angle of the probe to the tonsil

CHAPTER 7

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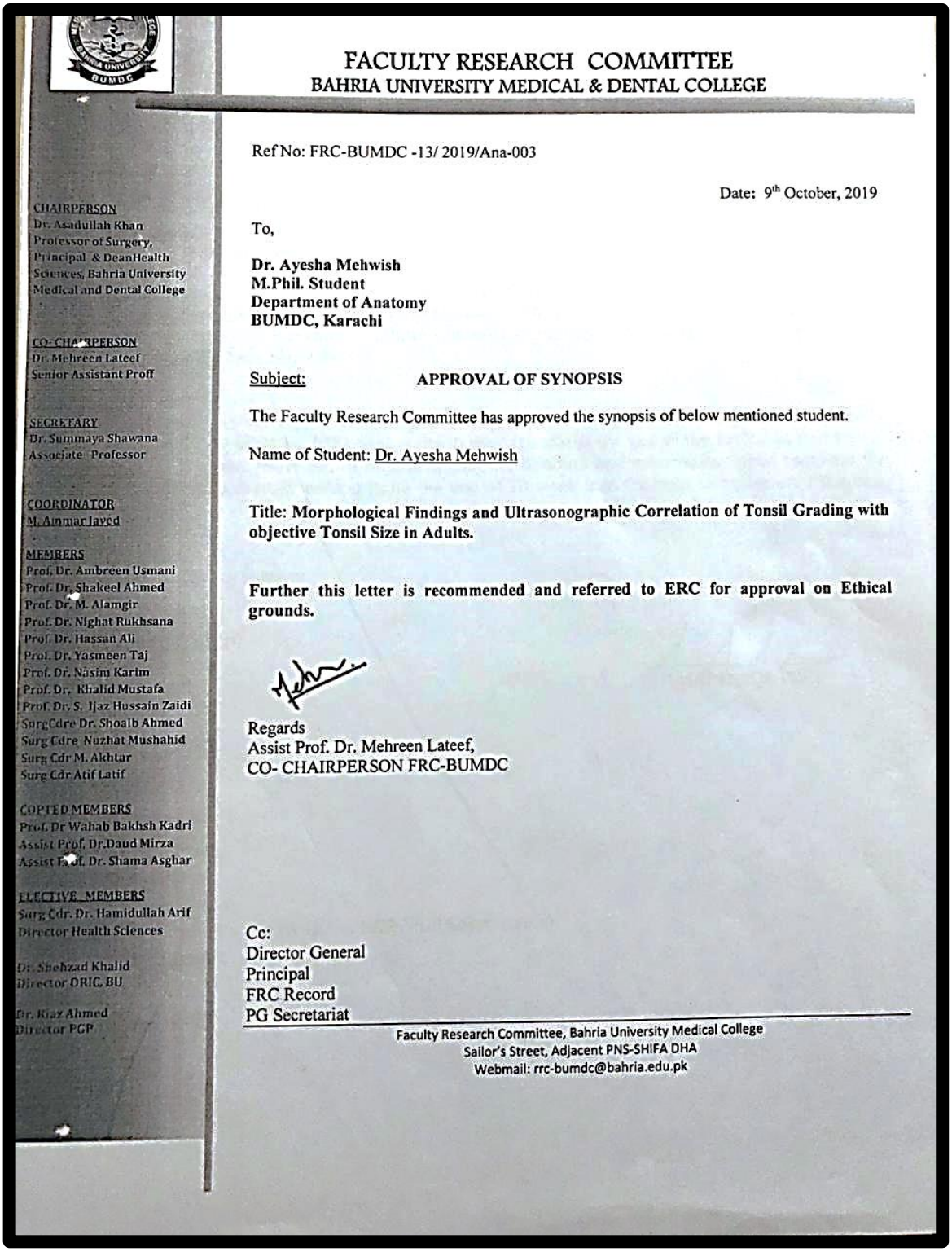
CHAPTER 8

APPENDICES

(A) FRC APPROVAL LETTER



FACULTY RESEARCH COMMITTEE
BAHRIA UNIVERSITY MEDICAL & DENTAL COLLEGE

Ref No: FRC-BUMDC -13/ 2019/Ana-003

Date: 9th October, 2019

To,

Dr. Ayesha Mehwish
M.Phil. Student
Department of Anatomy
BUMDC, Karachi

Subject: **APPROVAL OF SYNOPSIS**

The Faculty Research Committee has approved the synopsis of below mentioned student.

Name of Student: Dr. Ayesha Mehwish

Title: **Morphological Findings and Ultrasonographic Correlation of Tonsil Grading with objective Tonsil Size in Adults.**

Further this letter is recommended and referred to ERC for approval on Ethical grounds.

Regards
Assist Prof. Dr. Mehreen Lateef,
CO- CHAIRPERSON FRC-BUMDC

Cc:
Director General
Principal
FRC Record
PG Secretariat

Faculty Research Committee, Bahria University Medical College
Sailor's Street, Adjacent PNS-SHIFA DHA
Webmail: rrc-bumdc@bahria.edu.pk

CHAIRPERSON
Dr. Asadullah Khan
Professor of Surgery,
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Sciences, Bahria University
Medical and Dental College

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Director ORIC, BU

Dr. Riaz Ahmed
Director PGP

(B) ERC APPROVAL LETTER

BAHRIA UNIVERSITY MEDICAL AND DENTAL COLLEGE

Defence phase II, Sailor Street, adjacent to PNS Shifa, Karachi. Tel: 021-35319491-9

ETHICAL REVIEW COMMITTEE

LETTER OF APPROVAL

Date: 09-Jan-2020

PATRON
Prof. Asad Ullah Khan
Principal & Dean
Health Sciences(BU)

CHAIRPERSON
Dr. Quratul Ain
Omaeer

SECRETARY (Adhoc)
Dr Ambreen Surti

MEMBERS
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Prof Anis Jafarey
Ms Nighat Huda
Surg Cdre Amir Ejaz
Prof Reza H Syed
Ms Shabina Arif
Mr M Amir Sultan
Surg Lt Cdr Farah
Surg Lt Cdr Sadia

Dr. Ayesha Mehwish
M. Phil Student
Department of Anatomy
BUMDC-Karachi

Subject: Institutional Approval of research study

Title of Study: "Morphological Findings & Ultra-Sonographic Correlation of Tonsillar Grading with Objective Tonsillar Size in Obstructive Sleep Apnea in Young Pakistani Population "

Principal Investigator: Dr. Ayesha Mehwish, M. Phil Student Department of Anatomy, Bahria University Medical and Dental College.

Reference No: ERC 09/2020

Dear Dr. Ayesha Mehwish

Thank you for submitting the above mentioned study proposal. ERC Bahria University Medical and Dental College has reviewed this project in the meeting held on 3rd - Jan -2020 and gives approval. Kindly notify us when the research is complete.

Regards,

10/1/2020

DR. AMBREEN SURTI
Secretary
BUMDC

10/1/2020

DR. QURATUL AIN OMAEER
Chairperson
BUMDC

Cc:
DG-BUMDC
Principal BUMDC
Chairperson ERC

(C) CONSENT FORM URDU

اجازت نامہ

بالغوں میں مقصد ٹنسل سائز کے ساتھ ٹنسل گریڈنگ کی مورفولوجیکل اور الٹراسونگرافک ایسوسی

میں رضا کارانہ طور پر اپنی مرضی سے اس تحقیقاتی کام میں شامل ہونے کی رضا مندی دیتا/ دیتی ہوں جس کا مقصد OSA سے بچاؤ اور اس کی ابتدائی تشخیص ہے۔ یہ تحقیق OSA کے ان مریضوں میں جن کو خراٹوں کی شکایت ہو بہت زیادہ دن میں نیند آتی ہو جن کے ٹانسلز بڑھے ہوئے ہوں اور وزن میں اضافہ ہو یا ہو کی علامات اور ابتدائی تشخیص میں مدد دے گی اور مریض کو ماہرانہ علاجی مشورہ مہیا کرے گی۔

مجھے تفصیل سے اس تحقیقاتی کام میں شامل ہونے کی نوعیت اور اہمیت کے بارے میں آگاہ کر دیا گیا ہے اور جو تفصیلات مجھے اس بارے میں مہیا کی گئی ہیں ان کو اچھی طرح سمجھتا/سمجھتی ہوں۔

مجھے واضح کر دیا گیا ہے کہ میرے بیماری کی تشخیص اور میرے بارے میں معلومات کو انتہائی خفیہ رکھا جائے گا اور ان کو صرف علاج معالجہ کے لیے استعمال کیا جائے گا۔

مجھے تفصیل سے سمجھا دیا گیا ہے کہ میرے صحت کی نوعیت اور بیماری کی تشخیص اور طریقہ علاج کو جانچنے کے لیے الٹراساؤنڈ سے تحقیق کی جائے گی۔ اس مقصد کے لیے میں مکمل طور پر رضامند ہوں اور محقق کو الٹراساؤنڈ کی رپورٹ دینے کے لیے تیار ہوں۔

میں اس تحقیق کے لیے ضروری متعلقہ معلومات مکمل اور اپنی سمجھ کے مطابق محقق کو مہیا کرنے کے لیے تیار ہوں۔ مجھے یہ واضح کر دیا گیا ہے کہ اس تحقیق میں شامل ہونے کے لیے مجھے کوئی حوصلہ افزائی، مالی امداد یا رقم ادا نہیں کی جائے گی اور چونکہ مجھے مکمل اختیار ہے کہ میں اس تحقیقاتی کام سے کسی بھی وقت علیحدہ ہو جاؤں۔

مجھے ڈاکٹر عائشہ مہوش سے موبائل نمبر 0332-2436781 پر رابطہ کرنے کا مشورہ دیا گیا ہے۔

یا اپنی بیماری متعلق معلومات / ایمرجنسی کے لیے پی این ایس شفا ہسپتال جانے کا مشورہ دیا گیا ہے۔

مریض کا نام: _____

شوہر/ والد کا نام: _____

مریض کے دستخط: _____

محقق کا نام: ڈاکٹر عائشہ مہوش

محقق کے دستخط: _____

تاریخ: _____

(D) CONSENT FORM ENGLISH

WRITTEN INFORMED CONSENT FORM OF PATIENT

MORPHOLOGICAL AND ULTRASONOGRAPHIC ASSOCIATION OF TONSIL GRADING WITH OBJECTIVE TONSIL SIZE IN ADULTS

I am giving my consent to participate voluntarily and at my own will in the research project that aims for identification and early detection of obstructive sleep apnea (OSA). The project will evaluate markers for early diagnosis of OSA in the subjects with snoring, excessive day time sleepiness, increased tonsillar size, weight gain and will provide advice of symptomatic treatment to the subjects.

I have been explained in detail the nature and significance of participating in the project and I understand the provided explanation.
I have been told that findings of my disease and my data will be kept strictly confidential and will be used only for the benefit of community, publications and paper presentations.
I have been explained that ultra-sonographic investigation will be conducted to evaluate my health status and to diagnose and monitor my disease process. For this purpose, I fully agree to participate in this study and give ultrasound scan to the researcher

I also agree to give all relevant information needed, in full and to the best of my knowledge to the researcher. It is clarified to me that no incentive, financial assistance or reimbursement will be provided to me for participating in the study whereas I do have the right to withdraw from the study at any time.

I am advised to contact Dr. Ayesha Mehwish on mobile number 0332-2436781

or visit PNS Shifa hospital in case of query/ emergency related to my disease.

Name of Patient: _____

S/o, D/o, W/ o_____

Signature of Patient: _____

Name of Researcher: Dr. Ayesha Mehwish

Signature of Researcher: _____

Date: _____

(E) SUBJECT EVALUATION PROFORMA

Case Number:

Proforma Date:

Demographic Information

Researcher's Name	
Patient's Name	
Address	
Phone No	
Profession	
Gender	
Age	
Weight In Kg	
Height In m^2	
BMI	
History of smoking (yes/no)	
Alcohol intake (yes/no)	
Beetle nut/naswar (yes/no)	
Neck circumference in cm	
Blood pressure in mmHg	
History of stroke, coronary artery disease, heart failure, diabetes, thyroid disorders	
Snoring	

Epworth Sleepiness Scale

Activity	Never 0	Slight Chance 1	Moderate Chance 2	High Chance Of Dozing 3
1. Sitting and reading				
2.Watching television				
3. Sitting, inactive in a public place (e.g. a theatre or a meeting)				
4.As a passenger in a car for an hour without a break				
5.Lying down to rest in the afternoon when circumstances permit				
6. Sitting and talking to someone				
7. Sitting quietly after lunch without alcohol				
8. In a car, while stopped for a few minutes in traffic				

VISUAL ANALOG SCALE FOR NASAL OBSTRUCTION

Please tick the following

Braz J Otorhinolaryngol 2011;77:473-80

ANATOMICAL DATA

Tonsillar Grading

Brodsky Tonsillar Grading	Right Tonsil	Left Tonsil	Other Features
Grade I			
Grade II			
Grade III			
Grade IV			

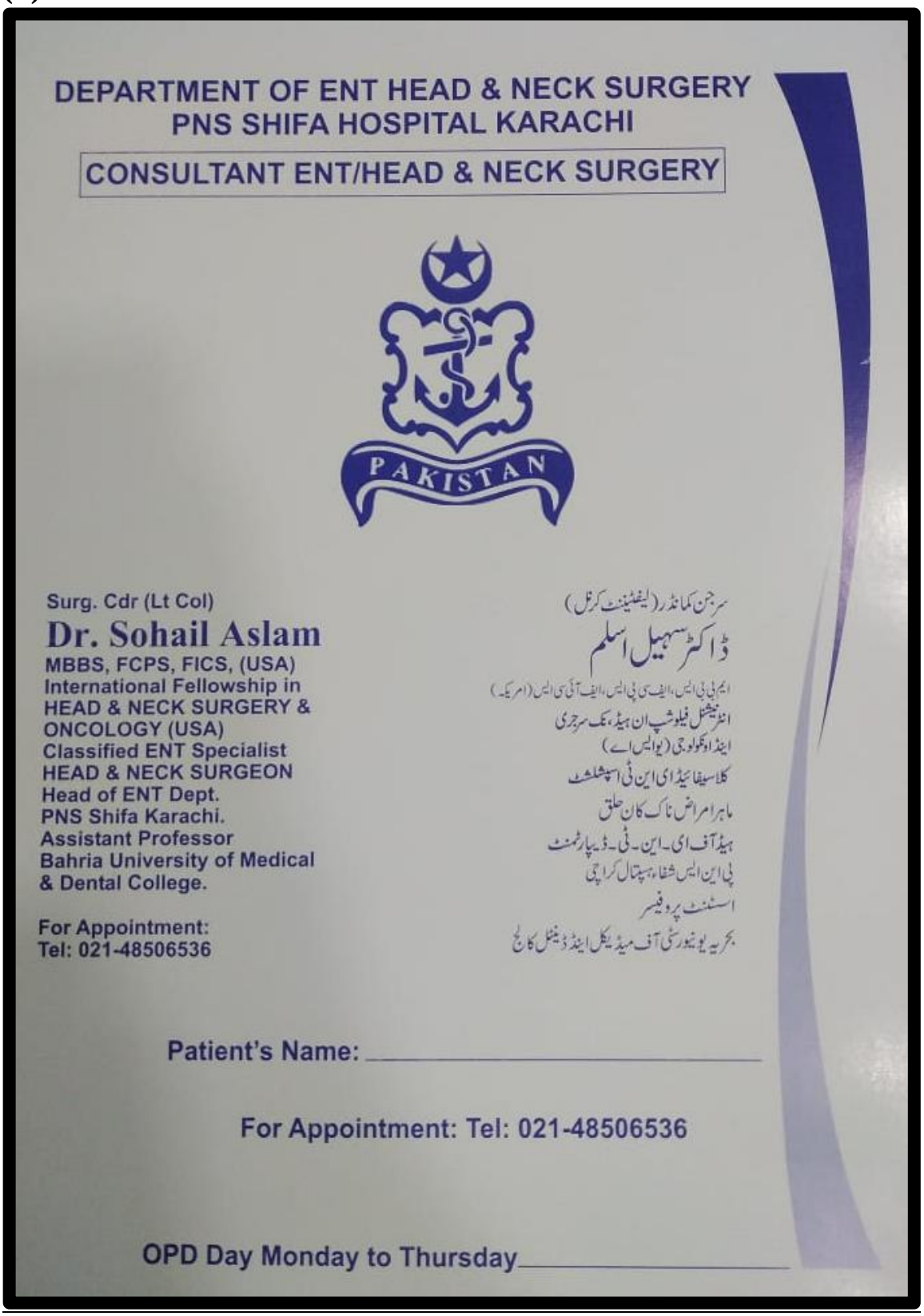
Tongue Grading

Modified Mallampati Scoring	
Grade I	
Grade II	
Grade III	
Grade IV	

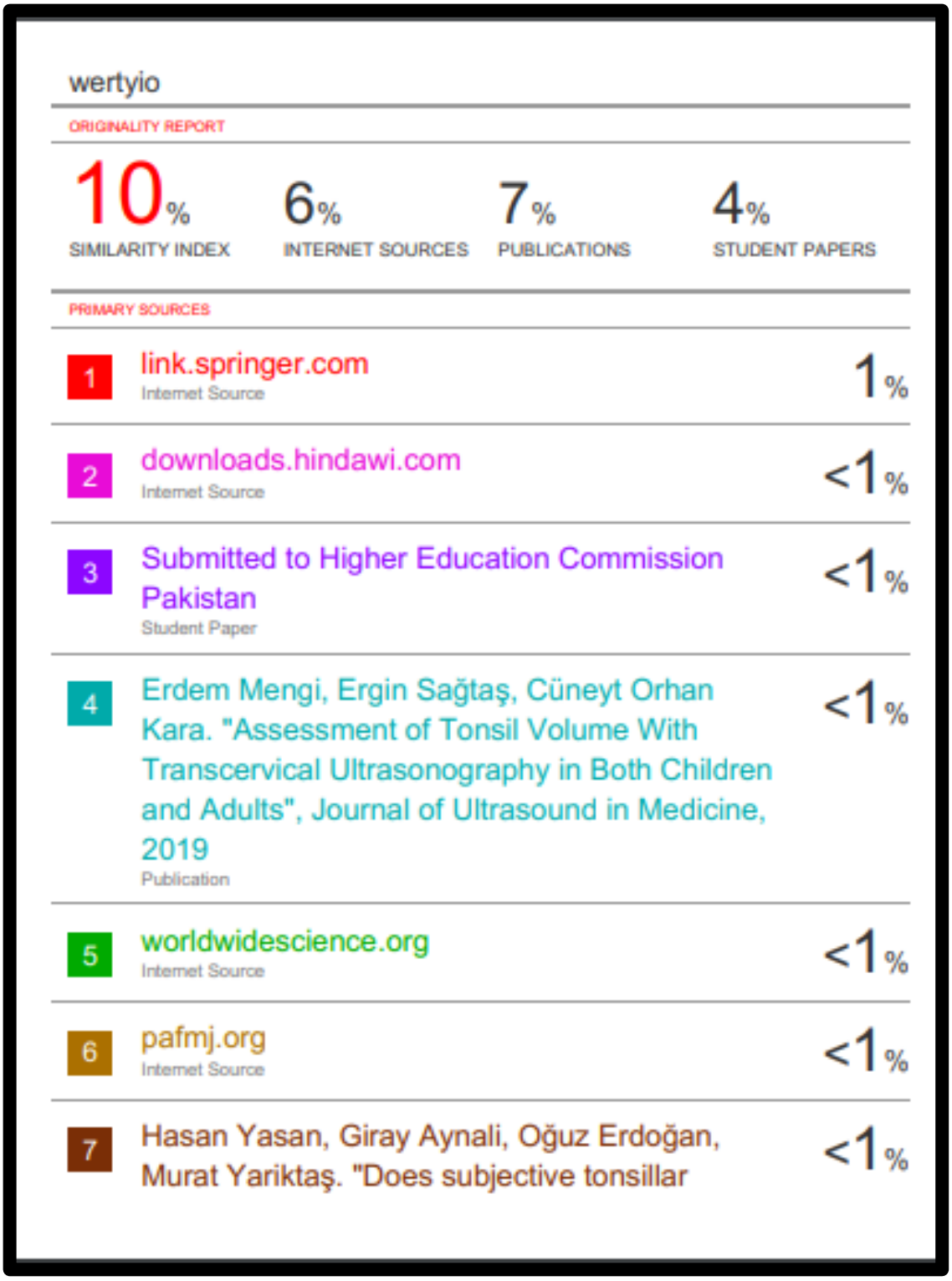
Ultra-sonographic Data

Right Tonsil	Left Tonsil	Other Features

(F) HOSPITAL CARD



(G) TURNITIN PLAGIARISM CHECK REPORT



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2	downloads.hindawi.com Internet Source	<1%
3	Submitted to Higher Education Commission Pakistan Student Paper	<1%
4	Erdem Mengi, Ergin Sağtaş, Cüneyt Orhan Kara. "Assessment of Tonsil Volume With Transcervical Ultrasonography in Both Children and Adults", Journal of Ultrasound in Medicine, 2019 Publication	<1%
5	worldwidescience.org Internet Source	<1%
6	pafmj.org Internet Source	<1%
7	Hasan Yasan, Giray Aynali, Oğuz Erdoğan, Murat Yariktaş. "Does subjective tonsillar	<1%