

# Correlation between Adenoidal–nasopharyngeal Ratio and Otitis Media with Effusion: A Cross-sectional Study

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## ABSTRACT

**Background:** Adenoid hypertrophy is one of the most common health problems affecting the pediatric population. This study aims to correlate the adenoidal–nasopharyngeal ratio (ANR) with otitis media with effusion (OME). If OME is left undiagnosed it can lead to long-term consequences like hearing impairment, learning and speech disabilities, and even chronic otitis media in children. The current study was a cross-sectional study conducted at a tertiary care center in Haryana, India. ANR was determined by dividing adenoidal depth with nasopharyngeal depth on the plain lateral radiographs and OME was diagnosed by tympanometry.

**Results:** The study consists of 70 children in the age group of 3–12 years with symptoms of adenoid hypertrophy. The children were almost similar in number in the three age groups we had selected with male preponderance. Otoscopy and tympanogram results were matching in our study. Types B and C tympanograms indicate middle-ear effusion seen in either one ear or both. In our study, type-A curves (non-diseased) were well correlated with low ANR, and types B and C curves (diseased) were well correlated with high ANR.

**Conclusion:** Adenoidal–nasopharyngeal ratio obtained from the X-ray will give an arithmetic measurement of adenoid mass with respect to available nasopharyngeal space. The simple outpatient tympanometry provides objective evidence of OME. The present study proved the positive correlation between ANR and OME by correlating ANR with tympanogram findings.

**Keywords:** Adenoid hypertrophy, Adenoidal–nasopharyngeal ratio, Otitis media with effusion, Tympanogram, X-ray nasopharynx.

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## BACKGROUND

Diseases of the adenoids and tonsils in children are very common presentations to clinicians. Adenoid is a collection of lymphoid tissue located in the posterosuperior wall of the nasopharynx adjacent to the choana and Eustachian tube opening. It attains maximum size between the ages of 3 and 7 years, starts regressing after 15 years of age and almost completely disappears by the age of 20 in most of the cases.<sup>1,2</sup>

Compared to the bony structure of the nasopharynx, the growth of adenoids is rapid in children predisposing them to obstructive symptoms. The symptoms of adenoidal obstruction are more common in younger ages due to the relatively small volume of the nasopharynx and the increased frequency of upper respiratory infections.<sup>3</sup> The relative size of the adenoids with that of the nasopharyngeal space is the major factor that determines nasopharyngeal obstruction.<sup>4</sup> Lateral radiograph of neck soft tissue is inexpensive, easily available, and comfortable for the child with a simple way to determine adenoid size, shape, and position.<sup>5</sup>

Adenoid hypertrophy has an important role in the development of OME which is the leading cause of childhood hearing impairment.<sup>6</sup> Infected and enlarged adenoids can cause Eustachian tube blockade which creates a negative pressure in the middle ear followed by effusion called OME also known as serous otitis media or secretory otitis media or glue ear.<sup>7</sup> If OME is left undiagnosed it can lead to long-term consequences like hearing impairment, learning and speech disabilities, and even chronic otitis media in children.<sup>6</sup>

Tympanometry is a simple non-invasive method that helps in the evaluation of children with OME. OME usually presents with a type-B curve, that is, a flat curve with no compliance

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peak. Sometimes, a type-C tympanogram may also be seen in OME.<sup>8</sup> Chronic serous otitis media may result in the formation of cholesteatoma, atrophic tympanic membrane, atelectasis in the middle ear and tympanosclerosis which may lead to permanent hearing loss.<sup>9</sup> Therefore, timely diagnosis and treatment of patients suffering from acute or chronic serous otitis media are crucial.

The adenoidal–nasopharyngeal ratio (ANR) obtained from a simple lateral neck X-ray can give an arithmetic measure of nasopharyngeal obstruction. As the ANR measures the bulk of adenoid mass relative to the available space in the nasopharynx, it can well denote the nasopharyngeal obstruction and the development of OME.<sup>10</sup> The purpose of this study is to determine the correlation between ANR obtained from soft tissue radiograph of the nasopharynx with OME diagnosed with the help of different

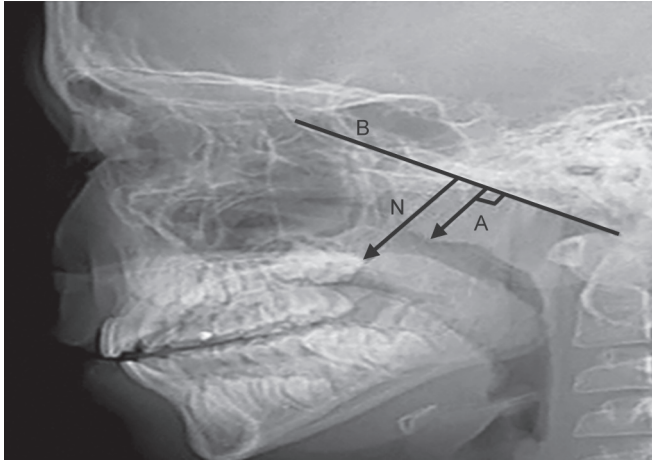


Fig. 1: The ANR measurement from lateral neck X-ray

types of curves in tympanometry so the exact utility of ANR in predicting OME can be authenticated.

## METHODS

An observational cross-sectional study was conducted at a tertiary-level center in Haryana, India. The study involved 70 patients in the age group of 3–12 years who presented with symptoms of adenoid hypertrophy. The patients with craniofacial anomalies, nasal septal deviation, sinonasal infection, and cerebral palsy were excluded from the study. The patients who were on treatment with steroid nasal spray and systemic steroids and who underwent adenoidectomy earlier were also excluded. Appropriate clearance was taken from the institutional scientific research committee and ethical committee.

A detailed history was taken and a thorough ear, nose, and throat (ENT) examination was done for all the children. All of them were subjected to digital X-ray soft tissue nasopharynx lateral view and Tympanometry. The adenoidal–nasopharyngeal ratio was determined from the digital X-ray and OME was diagnosed by clinical examination and tympanometry. The association between ANR and OME was statistically analyzed.

The adenoidal–nasopharyngeal ratio was assessed by the Fujioka method.<sup>4</sup> The adenoid size was determined by drawing a perpendicular line from a line drawn along the straight part of the anterior margin of basiocciput to a point of maximal convexity of adenoid (A in Fig. 1). Nasopharyngeal depth was determined by drawing a line from the anteroinferior edge of sphenobasioccipital synchondrosis to the posterosuperior margin of the hard palate (N in Fig. 1). The ANR was then determined by dividing adenoidal size with nasopharyngeal depth as shown in Figure 1.

Otitis media with effusion (OME) was diagnosed based on otoscopic findings such as bulged, retracted and dull tympanic membrane (TM) as well as tympanogram showing types B and C curves.

Collected data were entered in the Microsoft Excel spreadsheet. Mean  $\pm$  Standard deviation (SD) was evaluated for quantitative data. Percentage and proportion were calculated for qualitative data. Pearson correlation was found between Adenoid hypertrophy and Tympanometric findings using the statistical package for the social sciences (SPSS) software. Chi-square test was used for categorical data;  $p < 0.05$  was considered statistically significant.

Table 1: Distribution of tympanogram

Tympanogram	Unilateral		Bilateral	
	Number of cases	Percentage	Number of cases	Percentage
Type A	9	12.86	29	41.43
Type C	18	25.72	9	12.86
Type B	19	27.15	9	12.86

## RESULTS

The study was conducted on 70 children in the age group of 3–12 years of either sex who presented with symptoms of adenoid hypertrophy in the ENT outpatient department (OPD) after considering inclusion and exclusion criteria. The mean age was  $7.36 \pm 2.55$  years. In the study, 32.9% of children belonged to the age group less than 6 years, 32.9% in 7–8 years, and 34.3% in more than 9. The study comprised 40 males and 30 females with a ratio of M:F of 1.3:1.

### Clinical Profile

While considering symptoms, the majority of the children had nasal obstruction 67 (95.7%), mouth breathing 65 (92.8%), recurrent nasal discharge 65 (92.8%), and snoring 60 (85.7%) while decreased hearing and OSA was present only in 21 (30.0%) and 16 (22.9%) children respectively. On otoscopic examination, 30 children had normal-looking TM in both ears. There were 3 dull, 10 retracted, 2 bulged appearances while 17 dull with retracted and 16 dull with bulged appearances in combination.

### Tympanogram

In the present study, there were 29 children with type-A tympanogram bilaterally. Patients having either U/L or B/L type-C and U/L or B/L type-B tympanograms were considered abnormal and designated as diseased patients. There were 18 U/L, 9 B/L type-C tympanograms and 19 U/L, 9 B/L type-B tympanograms as depicted in Table 1.

### Adenoidal–nasopharyngeal Ratio

The ANR was calculated and based on the ratio; the children were divided into three groups. Group I had children having ANR  $< 0.6$ , group II had children having ANR between 0.6 and 0.8, and group III had children having ANR  $> 0.8$ . In our study, the maximum number of children 41 (58.6%) were in group II, 22 (31.4%) were in group I, and only 7 (10%) were in group III. Considering the other studies and the mean value of ANR from our study, a cutoff value of 0.7 was decided for predicting the occurrence of OME. In our study, 41 children (58.6%) had ANR below 0.7 and 29 (41.4%) had ANR above 0.7.

### Correlation between Adenoidal–nasopharyngeal Ratio and Otitis Media with Effusion

Types C and B tympanograms were analyzed separately. There was a total of 27 type-C tympanograms of which 17 had ANR above 0.7 which was statistically highly significant with  $p = 0.004$  as shown in Figure 2.

### Correlation between Total Type-B Tympanogram with Adenoidal–nasopharyngeal

There were total 28 Type B graph of which 22 had ANR above 0.7 with  $p$ -value 0.000 which is highly significant as shown in Figure 3.

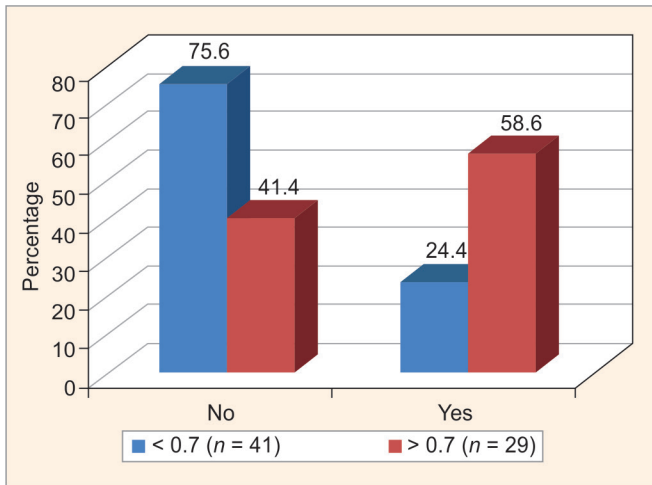


Fig. 2: Correlation between total type-C tympanogram and ANR

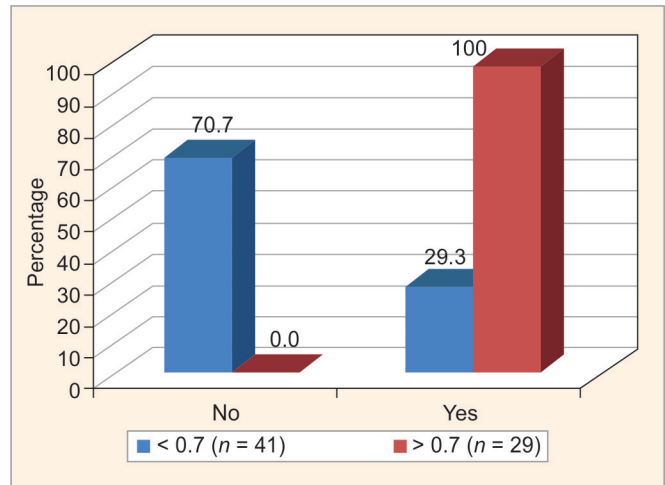


Fig. 4: Correlation between total type-B plus type-C tympanograms with ANR

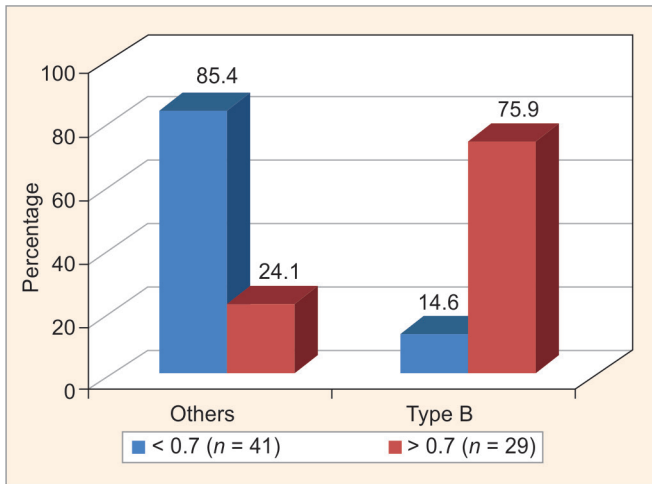


Fig. 3: Correlation between total type-B tympanogram and ANR

### Correlation between Total Type-B Plus Type-C Tympanogram with Adenoidal–nasopharyngeal

Finally, correlation was made between the total types B and C tympanograms (total children with OME) with ANR. There were 41 children who had types B and C tympanograms in the present study of which 29 had ANR above 0.7 which shows highly significant correlation. It was also observed that when ANR crosses 0.7 all the tympanogram became either C or B type as shown in Figure 4.

## DISCUSSION

Adenoid hypertrophy is a common problem in childhood. It plays an important role in the pathogenesis of OME, a common cause of hearing impairment in young children. Adenoid hypertrophy leads to OME by either Eustachian tube obstruction causing negative pressure in the middle ear or by acting as a reservoir for infection in the upper respiratory tract with edema of the nasopharyngeal opening of ET.<sup>11</sup> Adenoid hypertrophy can be assessed by different diagnostic methods such as digital palpation, X-ray, fiberoptic nasendoscopy (FNE), etc. In the present study, lateral soft tissue neck X-ray adenoid was used for assessing the enlargement of adenoids which is inexpensive and easily available.

Tympanometry is a simple, non-invasive, objective, and widely accepted procedure in the diagnosis of OME. Types B and C tympanograms in either ear were considered as diagnostic of OME. The tympanometric findings were correlated with ANR and assessed the predictive value of X-ray soft tissue nasopharynx in the early detection of OME.

The symptoms and signs of adenoid hypertrophy depend not merely on the absolute size of the adenoid mass but actually depend upon the available space in the nasopharynx. The major determinants of the nasopharyngeal obstruction are the absolute size of the adenoids and the size and shape of the nasopharyngeal space whose ratio is ANR which provides an arithmetic measure of nasopharyngeal obstruction. The ANR is much reliable in terms of assessing the patency of the nasopharyngeal airway.

In this study, ANR was divided into three groups. The maximum numbers of children (58.6%) were in the group of ANR between 0.6 and 0.8. There were 22 (31.4%) children in the group of ANR less than 0.6 and only 7 (10%) children had ANR above 0.8. The mean value of ANR was found to be  $0.67 \approx 0.7$  which was assigned as the cutoff value and ANR more than 0.7 is considered to have pathologically enlarged adenoids which point toward the development of OME. In our study, we had 41 (58.6%) cases with ANR less than 0.7 and 29 (41.4%) children with ANR above 0.7. All these 29 children got either type C or type B tympanogram in any one of the ears when they had undergone tympanometry.

Children aged between 3 and 12 years were included in the study and divided into 3 age groups with almost the same number of children in each. There were 23 children each in the age group less than 6 years and age group 7–8 years and 24 children in the age group 9–12 years. The age group less than 6 years showed a high ANR (mean ANR: 0.703), 7–8 years had mean ANR of 0.680 and the age group more than 9 years had mean ANR of 0.639. Fujioka et al.<sup>4</sup> in their study in 1979 and Orji and Ezeanolue<sup>8</sup> study in 2008 showed a similar trend in ANR with age. In a study by Adedeji et al.<sup>12</sup> in 2016, children in the 3–5-years age group showed a significant enlargement of adenoids. This age group also coincides with the ages when the rate of growth of adenoid tissues is at its peak. Recurrent upper respiratory tract infection along with the relatively small volume of the nasopharynx at this younger age make adenoid-related pathologies more common in this age group.<sup>8</sup>

Even though less than 6 years showed the highest mean ANR, the present study did not show a statistically significant correlation between age and ANR.

In this study, there were 40 (57.1%) males and 30 (42.9%) females with M:F of 1.3:1. The mean value of ANR in males was found to be  $0.673 \pm 0.110$  and for females, it was  $0.674 \pm 0.106$ . The mean ANR of males was almost the same as that of females ( $p > 0.05$ ), not showing any significant correlation between gender and ANR.

The majority of the children in the study were presented with nasal obstruction (95.7%), recurrent nasal discharge (92.8%), mouth breathing (92.8%), and snoring (85.7%) which are the classical presentation of adenoid hypertrophy. The decreased hearing was present only in 21 (30.0%) cases among them 16 had ANR above 0.7. Obstructive sleep apnea (OSA) was present only in 16 (22.9%) cases among them 13 had ANR above 0.7. Hence the study implicated that decreased hearing and OSA are the symptoms strongly suggestive of OME as compared to other symptoms of adenoid hypertrophy.

On otoscopic examination, there were different appearances of TM were found. We got different findings in both ears of the same patient also. The total number of patients with normal-looking TM was calculated in both ears. TM was bilaterally normal in 30 cases (42.85%) and TM was abnormal at least in any one of the ears in others. The different abnormal appearances include dull, retracted, and bulged. There were combinations of appearances like dull with retracted and dull with bulged also. They were also counted individually. Most of the abnormal cases were presented with dull retracted or dull bulged appearance. The total number of cases (U/L and B/L) with each of these abnormal appearances was calculated and correlated with ANR.

Furthermore, TM appeared dull in 3 cases, retracted in 10 cases, and bulged in 3 cases including unilateral and bilateral ears. There was a total of 17 cases with dull with retracted TM and 16 cases with dull with bulged TM. According to AHRQ guidelines 1994 (Agency for Health care, Research, and Quality), Otoscopic appearance is reliable in 2/3rd of cases of OME.<sup>10</sup>

In the present study, the otoscopic appearance of TM was well correlated with ANR. There were 30 children in the current study with normal TM out of which 29 had ANR value less than 0.7 which means the incidences of normal TM will have rare incidence in OME. Among the abnormal appearances only combined appearances of TM were significantly correlated with ANR. All three cases with dull TM had ANR below 0.7 ( $p = 0.137$ ) was not significant. Out of 10 cases with retracted TM, 5 had ANR above 0.5 ( $p = 0.552$ ) was not significant. Even though all the two cases having bulged TM had ANR above 0.7, the  $p$ -value was 0.08 and was not significant. The dull with retracted TM and dull with bulged TM were significantly correlated with ANR. Out of 17 cases having dull with retracted TM, 13 cases had ANR above 0.7 and out of 16 cases having dull with bulged TM 13 cases had ANR above 0.7. Both these appearances had  $p = 0.001$  which was highly significant. Among the different appearances of the TM dull with retracted and dull with bulged varieties were found to be more specific for OME in this study.

Karma et al.<sup>11</sup> in their study also explained about the different otoscopic appearances of TM and how they suggest middle-ear effusion. According to them, the predictive value of the normal-looking (color and/or mobility) TM for the absence of OME was good, but various abnormal TM findings were of varying value in the diagnosis of OME. Among the different TM findings, cloudiness, distinctly impaired mobility and bulging were considered reliable

indicators of OME, but redness, retraction and slightly impaired mobility were poor predictors of it. From our study, it is clear that otoscopic findings alone cannot be considered as a reliable determinant of OME and dull with retracted and dull with bulged appearances of the tympanic membrane may suggest the occurrence of middle-ear effusion.

Based on the tympanometric findings, children were divided into two groups. In the first group, the children with type-A tympanogram in both ears were included. They were considered as normal and non-diseased. The other group was designated as diseased which consist of children who had either U/L type-B or U/L type-C or B/L type-B or B/L type-C tympanograms. Both of these groups were correlated with ANR.

In the current study, 35 children had type-A tympanogram in the right ear and 32 children had type-A tympanogram in the left ear. 29 children had type-A tympanogram bilaterally which showed that these children even with symptoms of adenoid hypertrophy did not develop OME. Children with B/L A type tympanograms were included in group I and ANR of these children also found to be in the lower range ( $< 0.7$ ). The  $p$ -value was found to be 0.000 which shows a highly significant correlation between low ANR and type-A tympanogram that is the non-diseased group.

Then the correlation between the second group (diseased) and ANR was established. Initially, type-C tympanogram was correlated with ANR. There were 19 cases in the right ear and 17 cases in the left ear with type-C tympanogram. Otitis media with effusion could be diagnosed if we get type C or type B tympanogram even in any one of the ears. So, the total number of unilateral and bilateral C-type tympanograms were calculated and correlated with ANR.

The total type-C tympanograms were calculated which included patients having B/L type C tympanograms plus either ear having type C tympanograms in one ear while other ears may have either type A or type B curve. The total type-C tympanograms were correlated with ANR. There was a total 27 children with type-C tympanogram in the current study of which 17 had ANR above 0.7 ( $p = 0.004$ ) which suggested a significant correlation between type-C tympanogram and ANR.

Then, the correlation of type-B tympanogram with ANR was analyzed. There was a total 16 cases with type-B graph in the right ear and 21 cases with type-B tympanogram in the left ear. From this data, we calculated the U/L, B/L, and total type-B tympanograms in similar way as type-C tympanograms and correlated them with ANR. There was a total of 28 cases with type-B tympanogram of which 22 had ANR above 0.7 and  $p = 0.000$  which is highly significant. So, definite correlation was found between ANR and abnormal tympanograms when correlated separately.

Overall, 41 cases had both types C and B tympanograms which presented with symptoms of adenoid hypertrophy were diagnosed to have OME represents the total diseased patients. It was correlated out of these 41 cases, 29 had ANR value above 0.7 with  $p = 0.000$  which is a highly significant correlation that suggested that types C and B tympanograms are highly suggestive of OME. Also, we inferred from our study that as the value of ANR increased the tympanic membrane appearance becoming more abnormal and the incidence of types C and B tympanograms also increased.

The current study correlates with the study of Egeli et al.<sup>13</sup> which stated that the maximum number of B type tympanogram indicating middle-ear effusion and negative middle-ear pressure with ANR between 0.701 and 0.800. These findings correlate that

increase in adenoidal size will have a pathological effect on the middle ear in the form of negative middle-ear pressure and effusion.

Hamza and Ranjith<sup>1</sup> also showed a similar correlation between ANR and OME by grading adenoid hypertrophy based on ANR while grade II (ANR: 0.51–0.75) was considered as moderate enlargement. In their study, maximum numbers of children were in the grade-II classification which matched our study with maximum children in the 0.6–0.8 ANR group considering 0.722 as the mean ANR for which OME develops. Kumar et al.<sup>10</sup> in their study highlighted that the maximum number of pathological tympanograms were seen in the ANR between the ranges 0.601–0.700 and 0.701–0.800 which conclusively defines a positive correlation between ANR and the type of tympanogram similar to the present study as all tympanogram were pathological whenever ANR exceeded the cutoff value 0.7.

Toros et al.<sup>14</sup> conducted a study regarding the relationship of adenoid hypertrophy with tympanometry and concluded that the radiographic grading of the adenoidal size does not correlate with the tympanogram types and OME occurring in children with adenoidal diseases is independent of the adenoid size. This was also supported by Takahashi et al.<sup>15</sup> who stated that the mass effect of adenoid has a lesser impact in causing OME compared to the role of the adenoid as a source of inflammation and contamination. Both of these studies considering adenoidectomy are still important in the treatment as the pathogenic bacteria colonized over the adenoidal tissue are removed by the surgery. They did not find any correlation between the degree of adenoid size and OME.

According to the present study, the ANR has 100% sensitivity and more than 70% specificity. There is 100% negative predictive value and 70% positive predictive value also. These findings show a positive correlation between ANR and tympanogram and thus OME. We can predict the occurrence of OME by looking at the ANR and early treatment can be initiated which will prevent the further sequelae of OME in children.

## CONCLUSION

The role of adenoid hypertrophy in Eustachian tube dysfunction and the occurrence of OME is a known fact. Even though there are several methods for determining the magnitude of adenoid hypertrophy, lateral neck X-rays prevail as a popular choice as it is cheap, easily available and non-invasive. Adenoidal–nasopharyngeal ratio obtained from the X-ray will give arithmetic measurement of adenoid mass with respect to available nasopharyngeal space. The simple outpatient tympanometry provides objective evidence of OME. The present study proved the positive correlation between ANR and OME by correlating ANR with tympanogram findings.

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