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Original Research Article

Correlation between adenoid nasopharyngeal ratio and tympanometric findings in children with obstructive adenoid enlargement in JOS University Teaching Hospital, Nigeria

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ABSTRACT

Background: Adenoid enlargement plays a significant role in the pathogenesis of otitis media with effusion (OME). Adenoid nasopharyngeal ratio (ANR) of 0.67 was used as an indication for Adenoidectomy in children with obstructive adenotonsillar enlargement. OME is the commonest cause of reversible hearing loss in children. Tympanometry is an objective way the diagnosing OME. This study aimed to evaluate the correlation between ANR and tympanometry findings.
Methods: This study was a prospective cohort Hospital-based study conducted at Jos University Teaching Hospital, Nigeria between 5th of August 2020 to 5th of July, 2021. Ethical clearance was obtained. Participants had digital X-Ray postnasal space done and ANR calculated using Fujioka et al, method and subsequently had Tympanometry done and findings analysed using SPSS Version 26.0.
Results: A total of 95 patients were evaluated, 78.9% were in the age group of 2-5 years followed by 6-9 years (15.8%). There were 58(61.1%) males and 37(38.9%) females, with a M: F=1.6:1. ANR Mean was 0.76 and SD of ±0.17. Grading of the adenoids using Fujioka et al method showed 45 (47.4%) patients having grade 2 Adenoids and 50 (52.6%) patients having grade 3. Prevalence of type A, B and C tympanograms were 36.8%, 24.7% and 38.4% respectively. Strong Correlation between ANR and tympanometric findings was noted with a p value of<0.001 and correlation coefficient (r) value of 683.
Conclusions: This study showed strong correlation between ANR and tympanometric findings evidenced by high prevalence of types B and C tympanograms in patients with adenoid enlargement.

Keywords: Adenoid nasopharyngeal ratio, Hearing loss, Obstructive adenoid enlargement, Otitis media with effusion, Tympanometry

INTRODUCTION

Adenotonsillar hypertrophy is a common childhood disorder.[1,2] The adenoid constitutes the uppermost part of the ring of lymphoid tissues in the pharynx known as the Waldeyer's ring. It is located in the posterior superior wall of the nasopharynx adjacent to the choanae and Eustachian tube (ET) opening.[2,3] The size of the adenoids varies from child to child and in the same individual as the child grows. In general, it attains maximum size between ages of 3 and 7 years and then begins to regress.[2,3] Subsequently the growth of the nasopharynx increases while the soft tissue remains unchanged.[2,3] Chronically infected adenoids act as a reservoir in upper

respiratory infections with oedema and obstruction of the nasopharyngeal end of the Eustachian tube.[3,4] Enlarged adenoids can also lead to mechanical obstruction of the Eustachian tube leading to negative intratympanic pressure due to absorption of air.[5] Studies have shown that there is an increase in the number of mast cells and inflammatory mediators in adenoid tissues which are capable of binding immunoglobulin E (IgE) and releasing histamine and other inflammatory mediators following exposure to allergens.[6] The mediators released influence the mucociliary transport time, modify the airway function and increase the secretory activity of the mucosal cells of the middle ear.[6,7] The clinical effect of adenoid enlargement is related to its physical obstruction of the nasopharyngeal airway and Eustachian tube openings thus impairing their function leading to negative intratympanic pressure and subsequently OME. The larger the adenoids the more the risk of OME.[8] OME is a common Paediatric disease (it can affect adults also) that is often wrongly considered to be benign or harmless.[9,10]

However, it has been widely demonstrated that OME has both short and long-term impacts on audition, language, cognitive development and quality of life in children. Globally it is estimated that up to 90% of children experience at least one episode of OME before reaching school age, sixty percent (60%) of the episodes occur in the first two (2) years of life. Adenoid hypertrophy is an important aetiological factor in the causation of OME.[10,11]

Although there are a large number of prevalence studies of OME in general population of children, there have been less research on its prevalence in children having adenoidal obstruction and its association with negative middle air pressure.[12,13]

This study is necessary because Adenoid hypertrophy and OME are some of the commonest problems encountered by otolaryngologist because of the possible association between obstructive adenoid enlargement and OME and the known adverse effect of OME on learning, speech and language development. The result of this study would inform the otolaryngologist of the need to look for presence of OME in children with obstructive adenoid enlargement and may as well influence future approach to management of patients with OME and obstructive adenoid enlargement through adenoidectomy procedure.

Tympanometry provides useful quantitative information about the presence of fluid in the middle ear, mobility of the middle ear system and ear canal volume. Its use has been recommended in conjunction with more qualitative information (e.g., history, appearance and mobility of the tympanic membrane) in the evaluation of otitis media with effusion.[14] It provides an effective screening test for the detection of negative middle ear pressure.[15] Tympanogram is the graphical representation of admittance (or impedance of compliance) of the middle ear. The mobility or compliance of tympanic membrane is maximum when air pressure in the middle ear is equal to that of external auditory canal and the membrane is thus free from stress. Under normal conditions the pressure in the middle ear is maintained equal or close to atmospheric pressure by the functional Eustachian tube.[16]

The objective of this study was to evaluate the correlation between adenoid nasopharyngeal ratio (ANR) and tympanometric findings in children with obstructive adenoid enlargement.

METHODS

This study was a 1-year prospective cohort hospital-based study conducted between 5th of August 2020 to 5th of July, 2021, involving children aged 2-12 years of all gender with obstructive adenoid enlargement attending ENT clinic. To determine the minimum sample size (n), the following formula was used.[17]

$$n = 2\frac{(Z_\alpha + Z_\beta)2(p_1q_1 + p_2q_2)}{(p_2 - p_1)2}$$

Allowing for 10% attrition rate, a calculated minimum sample size of 95 was used.

Inclusion criteria

The inclusion criteria were patients aged 2-12 years with symptoms and signs of obstructive adenoid enlargement and consent to participate in the study (by the care giver/guardian).

Exclusion criteria

The exclusion criteria were patients/guardian who refuse to give consent to be part of the study, Patients with acute upper respiratory tract infections, patients with tympanic membrane perforation and children with anatomic abnormalities like cleft palate, syndromic children.

Ethical clearance was obtained from the Research Ethical Committee with reference number JUTH/DCS/IREC/ 127/XXIX/1779. This was in keeping with the Helsinki Declaration 1964 provisions.

Sampling technique

A consecutive sampling technique also known as total enumerative sampling was used for selection of study participants.

All children with diagnosis of Adenoid enlargement that met the inclusion criteria (which include recurrent rhinorrhoea, snoring, nasal blockage, mouth breathing, sleep apnoea, hyperactivity, daytime hypersomnolence and adenoid nasopharyngeal ratio of ≥0.5 calculated using Fujioka et al, method from X-ray post-nasal space). 31 were interviewed. If the respondent does not consent to participate in the study, the next respondent was selected (consecutive sampling method). This method

was used until the sample size was met. The data collection was done over a period of 12 months. A standard protocol for clinical assessment was done. The tympanometry was carried out in Audiology Laboratory using HOMOTH Tymp 4000 Tympanometer, Umbrella and mushroom probe tips (226 Hz).

Precautions taken include

The tympanometer and probe tip were cleaned with methylated spirit (i.e., free from dust and dirt and in compliance with local infection control standards), the calibration of the tympanometer was checked, appropriate size probe for age and canal size was used and properly fitted. Subject preparation was done which includes making sure there is no ear infection/discomfort through questioning e.g., ear discharge, pain or had surgery involving the ears and Otoscopy was done to make sure there are no contraindications e.g., otorrhea, acute otitis media, tenderness/soreness in the ear, otitis externa, foreign body in the ear canal and excessive wax. Questionnaire was administered (for those that cannot speak English, it was translated to them) in the language they understood. All participants satisfying the inclusion criteria were enrolled and bio-data and history were obtained. A physical examination including ear, nose and throat examination was performed after obtaining an informed consent (including surgery consent). Digital X-ray post nasal space was done and ANR calculated using Fujioka et al, method and Tympanometry was performed in the audiology laboratory using HOMOTH Tymp-4000 Tympanometer pre-operatively and findings noted. Type B tympanogram was considered as diagnostic of OME in this study. Data collected from the questionnaire was imported into IBM-Statistical Product and Service Solution (SPSS) version 26.0 for analysis. Basic univariate descriptive statistics of the sociodemographic characteristic were presented in frequencies and percentages.

Bivariate analysis such as McNemar's test, Pearson's correlation and Chi-square test were done to determine the relationship between ANR and tympanometric findings. Level of statistical significance was set at p value <0.05 (i.e., 95% confidence interval). The result was presented in tables and figures and in simple descriptive terms.

RESULTS

A total of 190 ears (95 patients) were evaluated. The age of the patients ranged from 2-12 years with a median age of 4 years (interquartile range 3.0-5.0). The most prevalent age group was 2-5 years (78.9%) followed by the 6-9 years group (15.8%) (Table 1). There were 58 (61.1%) males and 37(38.9%) females (Table 1).

Most patients presented with more than one symptom. It was observed that 46 (48.4%) presented with hearing impairment, 94 (98.9%) with nasal obstruction, 93 (97.9%) with snoring and 65 (68.4%) with mouth breathing. Other symptoms are sleep apnea, hyperactivity and rhinorrhoea and earache (Table 2).

Pre-operatively, 45 patients had grade 2 ANR and 50 patients had grade 3 ANR. Among the grade 2 ANR patients, 66.7%, 2.2% and 22.2 % had types A, B and C tympanograms respectively on the right ear and 75.6%, 2.2% and 10% on the left ear (Table 3).

Table 1: Age and sex distribution of patients.

Parameter	Frequency	%
Age (in years)		
2-5	75	78.9
6-9	15	15.8
10-12	5	5.3
Sex		
Male	58	61.1
Female	37	38.9

Median=4.0 years (IQR 3.0-5.0), n=95.

Table 2: Symptom profile of patients.

Parameter	Frequency	%
Hearing impairment		
Yes	46	48.4
No	49	51.6
Nasal obstruction		
Yes	94	98.9
No	1	1.1
Snoring		
Yes	93	97.9
No	2	2.1

Continued.

Parameter	Frequency	%
Mouth breathing		
Yes	65	68.4
No	30	31.6
Rhinorrhoea		
Yes	90	94.7
No	5	5.3
Hyperactivity		
Yes	64	67.4
No	31	32.6
Sleep apnoea		
Yes	91	95.8
No	4	4.2
Ear ache		
Yes	5	7.8
No	59	92.2

n=95 (190 ears).

Table 3: Adenoid nasopharyngeal ratio against pre-operative tympanometry findings.

Parameter	Tympanometry finding			Total	Df	X^2	P value
ANR categories	**Type A**	**Type B**	**Type C**				
Right ear							
Grade 2	30 (66.7%)	1 (2.2%)	10 (22.2%)	45 (100%)	2	47.160	<0.001
Grade 3	3 (6.0%)	27 (54.0%)	20 (40.0%)	50 (100%)			
Left ear							
Grade 2	34 (75.6%)	1 (2.2%)	10 (22.2%)	45 (100%)	2	41.774	<0.001
Grade 3	6 (12.0%)	18 (36.0%)	26 (52.0%)	50 (100%)			

Table 4: Tympanometry findings pre-op against post op for patients with grade 2 ANR findings.

Pre-Op	Type A (%)	Type B (%)	Type C (%)	Total (%)
Post- Op				
Right				
Type A	29 (96.7)	0 (0.0)	1 (3.3)	30 (100)
Type B	0 (0.0)	1 (100)	0 (0.0)	1 (100)
Type C	11 (78.6)	0 (0.0)	3 (21.4)	14 (100)
Total	40 (88.9)	1 (2.2)	4 (8.9)	45 (100)
Left				
Type A	32 (94.1)	0 (0.0)	2 (5.9)	34 (100)
Type B	1 (100.0)	0 (0.0)	0 (0.0)	1 (100)
Type C	7 (70.0)	0 (0.0)	3 (30.0)	10 (100)
Total	40 (88.9)	0 (0.0)	5 (11.1)	45 (100)

Tympanometry findings pre-operatively on the right for participants with grade 2 ANR showed type A tympanogram to be 30 and post-operatively changed to 29 (96.7%), 0 (0.0) and 1 (3.3%) type A, B and C tympanograms respectively. Type B tympanograms was 1 and remain unchanged while type C were 14 and changed to 11 (78.6%), 0 (0.0%) and 3 (21.4%) post-operatively while on the left type A were 34 and changed to 32 (94.1%), 0 (0.0) and 2 (5.9%) types A, B and C respectively. Type B was 1 and remain unchanged while type C were 10 and changed post-operatively to 7 (70%), 0 (0.0) and 3 (30.0%) types A, B and C respectively.

Tympanometry findings pre-operatively versus post-operatively for patients with grade 3 ANR on the right ears showed type A were 3 pre-operatively and remain unchanged post-operatively, type B were 27 and changed to 12 (44.4%), 13 (48.1%) and 2 (7.4%) types A, B and C tympanograms respectively. Type C were 20 and changed to 18 (90.0%), 0 (0.0%) and 2 (10%) types A, B and C tympanograms respectively while on the left type A tympanogram were 6 and remain unchanged, type B tympanograms were 18 and changed to 8 (44.4%), 7 (38.9%) and 3 (16.7%) types A, B and C tympanograms respectively. Type C tympanograms were 26 pre-operatively and changed to 24 (92.3%), 0 (0.0%) and 2 (7.7%) types A, B and C tympanograms respectively.

Table 5: Tympanometry findings pre-op against post op for patients with grade 3 ANR findings.

Right	Type A (%)	Type B (%)	Type C (%)	Total (%)
Post- Op				
Right				
Type A	3 (100.0)	0 (0.0)	0 (0.0)	3 (100)
Type B	12 (44.4)	13 (48.1)	2 (7.4)	27 (100)
Type C	18 (90.0)	0 (0.0)	2 (10.0)	20 (100)
Total	33 (66.0)	13 (26.0)	4 (8.0)	50 (100)
Left				
Type A	6 (100.0)	0 (0.0)	0 (0.0)	6 (100)
Type B	8 (44.4)	7 (38.9)	3 (16.7)	18 (100)
Type C	24 (92.3)	0 (0.0)	2 (7.7)	26 (100)
Total	28 976.0)	7 (14.0)	5 (10.0)	50 (100)

DISCUSSION

This prospective cohort hospital-based study conducted in the Department of ENT, Head and Neck Surgery, Jos University Teaching Hospital evaluated both the correlation between ANR and tympanometric findings in the studied participants.

Chronic adenoid enlargement is the most common cause of type C and B tympanogram patterns. Adenoid enlargement can result in types B and C tympanograms in two ways: Direct mechanical obstruction of ET by enlarged adenoids and obstruction of lymphatics draining the middle ear and the ET are the two mechanisms postulated.[3,4]

In this study majority of the children, 78.9% were in the age group of 2-5 years or the preschool age group followed by age of 6-9 years 15.8% and 10-12 years 5.3% age group. This finding concurred with a study in Nigeria by Nwosu et al, in which the pre-school age group of 2-4 years was predominant but with a relatively lower percentage of 52.9%.[1] However, in the school age group, this study contrasted sharply in both the age group and percentage composition of 15.8% as against the 23.5% obtained by Nwosu et al, James et al, in India found majority of the children (34.8%) to be within the age group of 5-7 years, this is at variance in both percentage and composition with the present study where majority (78.9%) were in the pre-school age group of 2-4 years.[1,18] This seems not to agree with the works of Fujioka et al, in which they found that the size of the adenoids varied from child to child and attained its maximum size between 4-8 years of age after which it regresses gradually till the age of 12 years.[19] The peak age incidence for middle ear effusion in their study corresponded to the period of maximum lymphoid hyperplasia in the nasopharynx.[19]

The median age of 4.0 years (interquartile range of 3-5 years) as found in this study concurred with the findings of both Nwosu and Orji et al, in Nigeria who reported a mean age of 4.0 years.[1,8] This is at variance with the works of James et al, where they reported a mean age of 5.3 years.[18] There were 61.1% males and 38.9% females giving a male: female ratio of 1.6:1. This slight male preponderance is similar to the findings by Nwosu et al, and studies conducted by other researchers.[1,8,18]

The classical presentation of adenoid enlargement is nasal obstruction, snoring, mouth breathing, sleep apnoea and recurrent rhinorrhoea others are hyperactivity, hearing impairment and earache. In this study snoring was observed in 97.9% of the patients, nasal obstruction in 98.9%, mouth breathing in 68.4%, rhinorrhoea in 94.7%, sleep apnoea in 95.8%, hyperactivity in 67.4%, hearing impairment in 48.4% and earache in 7.8%. Nasal complaints were the most common complaints compared to other systemic involvement. This could be attributed to the inability of the parents/caregivers to identify other systemic symptoms easily. James et al, found similar results but with differences in percentage composition such as snoring, nasal obstruction, mouth breathing and hard of hearing in 76.1%, 87%, 91.3 % and 34.8% respectively.[8,18,20,21]

In this study, Fujioka et al, method was used.[19] Grade 3 adenoid hypertrophy was found in 52.6% of the patients while grade 2 adenoid was found in 47.4% of the patients. This is close to the findings of James et al.[18] Though with variance in percentage composition with most (64.3%) of the children having grade 3 adenoid hypertrophy. This study also found a significant relationship between the adenoid grade and tympanometry findings pre-operatively (p value of <0.001) and r value of -683, the higher the grade of adenoid the more the prevalence of type B tympanogram which is in keeping with the findings of Orji et al, James et al, Basavaraju et al and Abdel et al.[8,18,20,21]

Pre-adenoidectomy, type A, B and C were 36.8%, 24.7% and 38.4% respectively. This showed type A and C tympanograms to be the most common findings followed by type B. This contrasts with the study by Nwosu et al, in Port Harcourt, where they found type A tympanogram to be the most common in 44.1%, type B tympanogram in

29.4% and type C tympanogram in 26.5%. Kumar et al, and James et al, in India and many others found type B tympanogram to be the most prevalent.[1,3,13,18,22,23] This could be attributed to the inclusion criteria of only type B tympanogram or patients with clinical features of OME pre-adenoidectomy in their studies.

Post-adenoidectomy type A, B and C tympanograms were 82.1%, 11.1% and 9.5% respectively. This showed type A tympanogram to be the most common finding followed by type C and B in decreasing order. The prevalence of pre-adenoidectomy OME using type B tympanogram was 24.7% compared to 7.4% post-adenoidectomy. This showed 30.0% resolution of OME six (6) weeks post-adenoidectomy (p value <0.001) which is significant. Ajayan et al, Maw and James et al, showed complete resolution of OME with higher percentages of 56.0%, 59.0% and 65.2% at six weeks and 3 months respectively.[16-18]

There was more unilateral type B tympanogram in this study than bilateral which contrasts with the study by Nwosu et al and Rajashekhar et al, who found more bilateral type B than unilateral.[1,2]

Prevalence of C tympanogram was found to be 38.4% pre-adenoidectomy and reduced to 9.5% post-adenoidectomy (p value of <0.001). This showed significant reversal of type C tympanogram to type A. This is in consonance with the findings by Ajayan et al and Sandooja et al, where they found 55.7% of type B tympanogram changed to type A and 15% to type C post-adenoidectomy.[17,20]

Pre- adenoidectomy prevalence of type A tympanogram was 36.8% and significantly increased to 82.1% post-adenoidectomy, about 44.7% of type B tympanograms and 85.7% of type C tympanograms changed to type A tympanogram showing significant reversal of type B and C tympanograms to type A. This is similar though varied in percentage composition with the studies conducted by Rajashekhar et al, James et al and Ajayan et al.[2,17,18]

Pre-operatively this study revealed 45 patients had grade 2 ANR, 71.1%, 2.2% and 26.7% had types A, B and C tympanograms respectively while post-operatively 88.9%, 1.1% and 10.0% types A, B and C tympanograms respectively showing increase in percentage of those with type A tympanogram and decrease in percentage of those with types B and C tympanograms. This shows resolution of OME and ET dysfunction.

Pre-operatively this study revealed 50 patients with grade 3 ANR out of which 9%, 45% and 46% had types A, B and C tympanograms respectively while post-operatively 61.0%, 20% and 9% had types A, B and C tympanograms respectively showing increase in percentage of those with type A tympanogram and decrease in percentage of those with types B and C tympanograms. This shows significant resolution of OME and ET-dysfunction. This study also showed high prevalence of type B and C tympanograms respectively in patients with adenoid enlargement pre-adenoidectomy with a significant reduction in prevalence of type C and B tympanograms post-adenoidectomy. This showed that adenoidectomy improved the outcome of OME.

This study has assessed the correlation between adenoid nasopharyngeal ratio and tympanometric findings and the role of adenoidectomy in resolution of otitis media with effusion and also the role of tympanometry in investigating patients with obstructive adenoid enlargement and found a statistically significant difference in pre-adenoidectomy and post-adenoidectomy category. X-ray post nasal space and tympanometry are highly recommended in children with obstructive adenoid enlargement for early detection of OME.

Parents and care givers especially kindergarten and primary school teachers should be sensitized on the significance of early detection using tympanometry as a screening tool and proper treatment instituted to prevent sequalae of OME thus improving hearing, language and speech development and school performance.

It is possible that obstructive adenotonsillar enlargement and OME may be caused by different aetiological factor/agent and so may be difficult to identify the particular aetiological factor.

CONCLUSION

This study revealed a strong correlation between Adenoid Nasopharyngeal Ratio and tympanometric findings evident by the increase in percentage of type B tympanogram in ANR grade 3 compared to ANR grade 2 and also proved that Adenoidectomy is a useful treatment option for adenoid enlargement in children with type B and C tympanograms. Early diagnosis of OME evidenced by type B tympanogram using simple investigation like X-ray postnasal space and tympanometry would aid in early identification of at-risk and established cases of OME (evidenced by type B tympanogram) and its sequalae thereby allowing early surgical intervention(adenoidectomy) if medical treatment failed.

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