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Adenoids in school-aged children

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Abstract
A total of 687 school children, aged six to 15 years, were examined clinically, radiologically and audiometrically. Lateral radiological examination of paranasal sinuses was carried out in 663 (96.5 per cent) children for evaluation of the size of adenoids. The size of the soft tissue shadow (adenoids) was assessed as normal or large. It was large in 133 (25 per cent) children, three times more frequently in seven-year-old than in 14-year-old children. The occurrence of adenoidal symptoms (blocked nose, mouth breathing, snoring, snuffling or rhinitis) varied from 14.3 to 30.1 per cent in children with large adenoids compared to 7 to 9.8 per cent in children with normal adenoids. Logistic regression analysis revealed that only recurrent snoring and the child's age were significantly associated with radiologically large adenoids. The hearing thresholds were 1.1 to 4.2 dB poorer and mean middle ear pressure values were 60 to 70 mmH_2O lower in children with large adenoids compared to those with normal size adenoids. Large adenoids have an influence on the hearing level of a child, but probably via the negative middle ear pressure.

Key words: Adenoids; Child; Adolescence; Acoustic impedance tests; Hearing tests

Introduction

Clinical assessment of adenoidal size in small children by means of posterior rhinoscopy is difficult and unreliable (Dolen *et al.*, 1990). Therefore, clinicians often use lateral radiography of the soft tissue of the nasopharynx for assessing the size of adenoids and palatal airway (Hibbert and Tweedie, 1977; Fujioka *et al.*, 1979; Qvarnberg, 1981; Tankel and Cheesman, 1986; Gates *et al.*, 1989).

Adenoids increase in size rapidly after birth, attain their maximum size at the age of four to six years, remain the same until eight to nine years, and then gradually begin to involute. The palatal airway reduces slightly from age three to five years, but after that grows rather steadily up to 19 years (Fujioka *et al.*, 1979; Jeans *et al.*, 1981b). The palatal airway is larger in boys than in girls from 13 years onwards while no sex difference in the size of the adenoids or in the adenoidal–nasopharyngeal ratio could be found in any age groups below 15 years (Pruzansky, 1975; Fujioka *et al.*, 1979; Jeans *et al.*, 1981a).

The size and shape of the nasopharygneal space, the absolute size of the adenoids and the palatal airway are the major factors that determine nasopharyngeal obstruction. Adenoidal hypertrophy may give rise to nasal obstruction, snoring, mouth breathing, hyponasal speech, running nose and sneezing (Dolen *et al.*, 1990). Hibbert and Tweedie (1977) related the symptoms of snoring and mouth breathing to adenoidal weight in children aged seven years or over. Tankel and Cheesman (1986) found that snoring and nasal speech were significantly associated with the percentage obstruction caused by the adenoidal shadow. Maw *et al.* (1981) have shown a significant relationship between adenoidal volume and a nasal obstruction score derived from combined assessments of mouth breathing and nasal speech.

The obstruction of the nasopharynx by the adenoids and consequent mouth breathing may explain why the normal growth and development of the jaws is altered and may result in open-bite occlusion (Linder-Aronson, 1970). The relationship of large adenoids with different diseases has been often suggested. There are studies documenting the relationships in children between secretory otitis media (SOM) and symptoms of adenoidal hypertrophy, i.e. nasal obstruction (Mills and Brain, 1985), snoring (Takasaka, 1990), mouth breathing (Van Bon *et al.*, 1989) and recurrent sneezing and rhinorrhea (Mills and Brain, 1985).

Qvarnberg (1981) has reported a significant relationship between the large radiographical adenoids and maxillary sinusitis in children under nine years old. Fujita *et al.* (1988) evaluated the efficacy of adenoidectomy for maxillary sinusitis in four to seven year-old children and they found a significant improvement in sinusitis after the operation.

No studies on the association between the size of the adenoids and hearing in school children have been published. Several authors have, however, presented evidence that hearing is impaired by adenoidal obstruction of the eustachian tubes (Guild *et al.*, 1940; Crowe and Burnam, 1941; Marttila, 1986). Here, the hearing loss is caused by middle ear disorders, chiefly catarrhal inflammations of the middle ear cleft. Many earlier studies have reported impairment of high tones in children with large adenoids and improvement in hearing as a result of the regression of middle ear lesions after operation or radiation of the nasopharyngeal lymphoid tissue (Guild *et al.*, 1940; Crowe

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and Burman, 1941; Crowe *et al.*, 1942). Alhady and Sharnoubi (1984) have reported that the mean air–bone gap in 40 children, aged two to six years, with symptoms of obstructing adenoids, was 15 dB.

There is more information available on the influence of enlarged adenoids on tympanometry. Alhady and Sharnoubi (1984) reported that the mean middle ear pressure in children with enlarged adenoids was 226 mmH_2O. The difference was statistically highly significant compared to the middle ear pressure of 19 mmH_2O in children with healthy ear drums. It is, however, very likely that children with hypertrophied adenoids had middle ear troubles, because 58 per cent of children had type C2 or B-tympanograms. Tuohimaa and Palva (1987) examined 67 children (mean age seven years to two months) with healthy tympanic membranes, by means of impedance audiometry, before and three months after adenoidectomy and/or tonsillectomy. The mean pre-operative middle ear pressure was 67.3 mmH_2O and post-operatively it was 21.9 mmH_2O ($p<0.001$). The middle ear pressure was dependent on the size of adenoids evaluated peroperatively by inspection: it was 45.0 mmH_2O in small, 55.7 mmH_2O in medium-sized, and 94.6 mmH_2O in large adenoids. The difference between the groups with small adenoids and large adenoids was highly significant.

The purposes of the present study are firstly to determine the radiological size of adenoids in the lateral projection of X-ray of the maxillary sinuses, secondly to find out whether there is any association between medical history and clinical findings and the size of adenoids and thirdly to find out whether radiological large adenoids have any influence on hearing thresholds or impedance findings in school-aged children.

Material and methods

Material

The study population consisted of 692 school children, i.e. 32.9 per cent of the source population of 2381 elementary school children living in a town of 20 000 inhabitants in southwestern Finland. These children were accepted for the study as they satisfied the criteria of age and residence. The only drop-outs were five children who did not want to participate in the study. Thus, 687 school children underwent a routine ENT examination including otomicroscopy, pure tone audiometry, tympanometry, stapedial reflex measurements and ultrasound and X-ray examination of the maxillary sinuses with lateral projection, for the assessment of the size of adenoids. The children were in three different school grades (I, IV and VIII) and the mean age was seven years in the first grade, 10.2 years in the fourth grade and 13.8 years in the eighth grade. The present study is part of a large epidemiological study of school-aged children carried out in 1983–1985.

Questionnaire

The questionnaire sent in advance and completed by the parents was supplemented by the author himself at the examination and from the files of the local hospital. A comprehensive and thorough examination of the ear, nose and throat was performed for every child. However, four school children in the first grade were so afraid that the examination remained incomplete. Data concerning these children were included in the material when the examination could be performed.

X-ray

The radiological examination of paranasal sinuses and adenoids was carried out in 663 (96.5 per cent) out of 687 children. A total of 531 (77.1 per cent) school children were included in the present material because they had not undergone a previous adenoidal operation. The radiographs were taken with the child in an upright position using horizontal beams. The lateral projection was used in estimating the relative size of adenoids. If a soft tissue mass in the roof of the nasopharynx was $\geqslant 2/3$ of the total width of the nasopharynx, the size of adenoids was considered large. If it was equal to or over 1/3 but less than 2/3, the adenoids were recorded as medium-sized. If the shadow was less than 1/3 of the width of the nasopharynx, the adenoids were recorded as small. These two latter groups were considered normal-sized adenoids.

Before every X-ray, the parents were asked to give permission for their child to participate in the X-ray examination. According to the study design, X-ray pictures were taken even of symptomless children. At the time when the study was started it was not necessary to obtain the consent of the Ethical Committee, and such was the case for this study. Nowadays, consent would have to be obtained.

Audiometry

Hearing was tested in a sound-proof booth by pure tone audiometry (Madsen TBN 80; Madsen electronics, Denmark), and air conduction thresholds for both ears were determined individually at nine frequencies between 0.125 and 8 kHz. Pure tone average (PTA) was obtained by calculating the average of the thresholds of 0.5, 1 and 2 kHz.

Impedance measurements

Tympanometric and stapedius reflex examinations were performed using an automatic, computerized impedance meter (GSI 28 Auto Tymp; Grason-Standler, Inc., UK). The probe tone was 226 Hz, and it was presented at a given intensity of 85 dB SPL to the ear canal via the handheld probe with a pump speed of 600 daPs/s. The ear canal volume, compliance and middle ear pressure were measured and the relative gradient was calculated. The pressure range was +200 to −400 daPa. The ipsi- and contralateral stapedius reflex measurements were made in each child at stimulus frequencies of 0.5, 1, 2 and 4 kHz. A stapedial reflex was elicited by presenting a stimulus of 75 to 110 dB HL to the ear canal. Each selected frequency was presented at up to three different intensity levels in 10 dB steps, set by the manufacturer.

Statistics

Univariate associations between potential explanatory factors and radiologically large adenoids were first tested with Pearson's Chi-square test. Similar significant ($p<0.05$) explanatory factors were grouped and were assessed with step-wise logistic regression analysis. Factors showing significant association in the stepping were

TABLE I
THE NUMBER AND PERCENTAGE DISTRIBUTION OF THE SIZE OF SOFT TISSUE SHADOW (ADENOIDS) OF THE LATERAL VIEW IN THE POSTERIOR NASOPHARYNGEAL WALL IN NON-ADENOIDECTOMIZED CHILDREN, AND THAT OF OPERATED (ADENOIDECTOMIZED) CHILDREN ACCORDING TO SCHOOL GRADE

	Grade I		Grade IV		Grade VIII		Total	
	n	%	n	%	n	%	n	%
Radiological size of adenoids								
Small	9	4.7	9	6.1	33	17.2	51	9.6
Medium-sized	107	56.0	104	70.3	136	70.8	347	65.4
Large	75	39.3†	35	23.6‡	23	12.0	133	25.0
Total material	191	100.0	148	100.0	192	100.0	531	100.0
Adenoidectomy								
No	196	81.0	152	82.6	203	77.8	551	80.2
Yes	46	19.0	32	17.4	58	22.2	136	19.8
Total material	242	100.0	184	100.0	261	100.0	687	100.0

†$p = 0.002$. Grade I *versus* IV; $p<0.0001$ Grade I *versus* VIII.
‡$p = 0.005$ Grade IV *versus* VIII.

forced into the final model. The distribution of numerical values between study groups was compared with one-way analysis of variance and Bonferroni's multiple comparison procedure.

The analysis of variance (ANOVA) for repeated measurements with various grouping factors and one or two within factors (ear, frequency) was used to study the significances in hearing thresholds and in impedance findings. The p-values given in connection with ANOVAs are Greenhouse–Geisser probabilities, when the covariance matrix of measurements was not uniform.

Results

The size of adenoids

The distribution of the size of the posterior nasopharyngeal soft tissue shadow (adenoids) in children who had not undergone adenoidectomy, is presented in Table I which also shows the number and percentage of children previously adenoidectomized.

Radiologically large adenoids were found in 133 children (25 per cent) out of the total 531 unoperated children. A large shadow was found statistically significantly more often in children of Grade I than in children of the other grades. The difference was also significant between Grades IV and VIII. Small and medium-sized adenoids were found in 9.6 and 65.4 per cent, respectively.

Of all the children, 629 (91.5 per cent) cooperated enough for the nasopharyngeal mirror examination (Table II). The mirror examination succeeded more frequently for older children than for children in Grade I.

In the present study, good consistency was found between previous adenoidectomy and mirror examination of the nasopharynx. Of the children in the first, fourth and eighth grade, 19, 17.4 and 22.2 per cent had undergone adenoidectomy, respectively (Table I), whereas no adenoidal tissue was found on mirror examination in 15.7, 14.1 and 17.6 per cent, respectively (Table II). Thus, adenoidal tissue could be found on mirror examination in approximately three to five per cent in children who had undergone adenoidectomy.

TABLE II
NASOPHARYNGEAL MIRROR FINDINGS IN DIFFERENT AGE GROUPS IN CHILDREN WHO WERE ABLE TO BE EXAMINED

	Grade I		Grade IV		Grade VIII		Total	
Finding	n	%	n	%	n	%	n	%
Adenoids								
Not visible	38	15.7	26	14.1	46	17.6	110	16.0
Visible	177	73.1	146	79.4	196	75.1	519	75.5
No data*	27	11.2	12	6.5	19	7.3	58	8.5
Total	242	100.0	184	100.0	261	100.0	687	100.0

*No data means unsuccessful mirror examination.

Factors related to large adenoids

The occurrence of symptoms relating to hypertrophied adenoids is presented in Table III. The only significant difference between the grades was that double the number of children had habitual snoring in the first grade compared to the other grades ($p = 0.002$). The frequencies and significances of potential explanatory factors of large adenoids are presented in Table IV.

A significant connection could be found between radiologically large adenoids and recurrent snoring, habitual mouth breathing, four or more attacks of acute otitis media, hearing loss during common cold/AOM, common cold, cough or hearing loss at time of examination, purulent or mucous nasal secretion, nasal eosinophilia, large palatine tonsils, abnormal ultrasound or X-ray of maxillary sinuses or secretory otitis media. As to the tympanic membrane findings, a significant correlation could be found between the occurrence of large radiological adenoids and, on the other hand, of pathological colour (dull, red or amber), position (retracted), mobility (decreased) of pars tensa and retraction of pars flaccida.

In the analysis of logistic regression, recurrent snoring and school grade were distinctly related to radiologically large adenoids (Table V).

Audiometric and impedance findings

The mean hearing thresholds in children with large or small/medium-sized adenoids are illustrated in Figure 1. In the analysis of variance the hearing thresholds of children with large adenoids were significantly ($p<0.0001$) poorer than those of children with normal (small/medium-sized) adenoids. The strong interaction ($p = 0.003$) between frequency and radiological adenoids showed that the difference in hearing thresholds was dependent on the frequency. When the differences between the groups were studied by means of the two-sample t-test, significant differences were found at all frequencies from 0.125 to 4 kHz (Table VI). The differences in the hearing thresholds between the groups were more pronounced and more significant in the left ear than in the right ear. The

TABLE III
THE REPORTED FREQUENCY OF RECURRENT SIGNS AND SYMPTOMS OF HYPERTROPHIED ADENOIDS IN SCHOOL-AGED CHILDREN

	Grade I n = 242		Grade IV n = 184		Grade VIII n = 261		Total n = 687	
	n	%	n	%	n	%	n	%
Sneezing	10	4.1	9	4.9	18	6.9	37	5.4
Blocked nose	29	12.0	23	12.5	27	10.3	79	11.5
Mouth breathing	29	12.0	23	12.5	31	11.9	83	12.1
Snoring	45	18.6	17	9.2	25	9.6	87	12.7
Snuffling	36	14.9	27	14.7	27	10.3	90	13.1
Rhinitis	28	11.6	25	13.6	46	17.6	99	14.4

TABLE IV

THE RELATIONSHIP OF DIFFERENT VARIABLES WITH THE FINDINGS OF RADIOLOGICALLY SMALL/MEDIUM-SIZED OR LARGE ADENOIDS IN THE LATERAL PROJECTION OF MAXILLARY SINUSES. SIGNIFICANCES ARE GIVEN BETWEEN SMALL/MEDIUM-SIZED AND LARGE ADENOIDS. NUMBERS ARE GIVEN AS PERCENTAGES

	Radiological size of adenoids			
Variable	Small/medium (n = 398)	Large (n = 133)	*p* value	Odds ratio
Medical history				
Family allergy	42.8	45.4	NS	1.1
AOM of parents	11.5	15.3	NS	1.4
Allergy	17.5	22.1	NS	1.3
Recurrent common cold	11.6	15.0	NS	1.4
Recurrent blocked nose	9.8	14.3	NS	1.5
Recurrent snuffling	9.8	15.0	NS	1.6
Recurrent snoring	7.0	30.1	<0.0001	5.7
Habitual mouth breathing	8.5	16.5	0.009	2.1
Recurrent URTI	11.5	8.4	NS	0.7
Sinusitis	7.6	8.3	NS	1.1
Attacks of AOM (once or more)	58.8	66.7	NS	1.4
Attacks of AOM (twice or more)	40.2	49.2	NS	
Attacks of AOM (four or more)	29.0	42.9	0.04	1.8
Attacks of AOM during previous year	26.1	34.1	NS	1.5
Previous paracenteses (once or more)	30.3	31.8	NS	1.1
Hearing loss during common cold/AOM	4.6	13.8	0.0003	3.4
Hearing loss detected audiometrically	3.5	6.8	NS	2.0
Signs and symptoms				
Common cold at time of examination	36.7	47.4	0.03	1.5
Cough at time of examination	3.0	8.3	0.01	2.9
Hearing loss at time of examination	1.0	5.3	0.007	5.5
Clinical findings				
Nasal secretion (purulent or serous)	31.1	45.6	0.003	1.8
Nasal eosinophilia (++ or +++)	3.3	8.6	0.01	2.7
Septum deviation	10.1	5.3	NS	0.5
Large or operated palatine tonsil	0.3	3.0	0.003	22.7
Abnormal ultrasound of maxillary sinuses	14.6	22.6	0.03	1.7
Abnormal maxillary sinus X-ray	22.9	37.1	0.001	2.0
Secretory otitis media (SOM)	2.4	8.7	0.02	1.8
Abnormal colour of tympanic membrane	7.4	22.3	<0.0001	3.6
Abnormal position of tympanic membrane	4.8	15.8	<0.0001	3.7
Abnormal motion of tympanic membrane	5.4	10.1	0.05	2.0
Retraction of pars flaccida	9.4	20.3	0.0004	2.5

mean pure tone averages (PTA) in children with radiologically small/medium -sized or large adenoids were 0.0 dB (SD 5.4) and 2.9 dB (SD 7.6), respectively ($p<0.001$).

The results of impedence audiometry in children with radiologically large or small/medium-sized adenoids are presented in Table VII. The ear canal volumes were lower in children with radiologically large adenoids than in children with normal adenoids. In the sex and grade (age) adjusted analysis of variance the difference in ear canal volumes was nonsignificant ($p = 0.31$). Middle ear pressures were lower in children with large adenoids than in children with normal adenoids and the difference was highly significant ($p<0.0001$) When each grade was studied separately, the differences were highly significant ($p<0.0001$) in the first and the fourth grade but controversial in the eighth grade ($p = 0.31$ right ear and $p = 0.05$ left ear). The compliance and relative gradient values were, however, at the same level.

The classification of tympanogram curves into A, C1, C2 and B-groups showed highly significant differences ($p<0.0001$) between the groups of radiological adenoids. Almost all curves were type A in children with normal adenoids whereas this was true in only 67 per cent of children with large adenoids (Figure 2).

The percentage of non-elicitable ipsilateral and contralateral stapedial reflexes was higher at all four frequencies in the ears of children with radiologically large adenoids compared to the ears with radiologically small/

TABLE V

FACTORS ASSOCIATED WITH RADIOLOGICALLY LARGE ADENOIDS IN SCHOOL-AGED CHILDREN. LOGISTIC REGRESSION ANALYSIS

Variable	Odds ratio	95% Confidence interval	*p* value
Recurrent snoring	4.8	2.6–8.8	<0.0001
School grade (I *versus* IV)	2.0	1.2–3.5	0.01
School grade (I *versus* VIII)	4.1	2.3–7.4	<0.0001
Retraction of pars flaccida	2.4	1.1–5.1	0.02
Nasal eosinophilia (++ or +++)	2.6	1.0–6.5	0.04
Abnormal sinus X-ray	1.6	0.9–2.6	0.08
Hearing loss during common cold/AOM	1.8	0.7–4.3	0.19
Abnormal colour of tympanic membrane	1.6	0.8–3.4	0.21

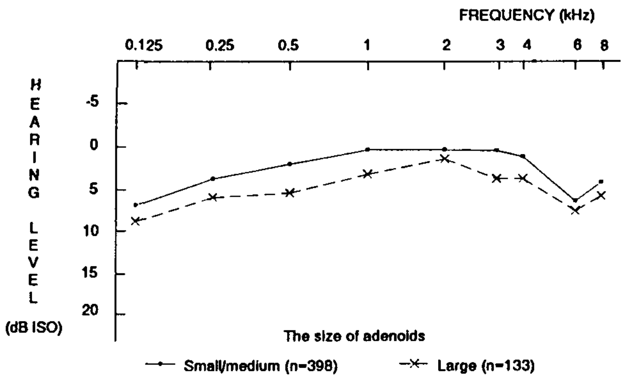

FIG. 1

Mean air conduction hearing thresholds in school children with radiologically normal or large adenoids (n = Number of children).

medium-sized adenoids. The differences were significant at least at the significance level below 0.05.

Discussion

The size of adenoids

A single soft-tissue lateral picture of the nasopharynx without the use of a cephalostat was used in the present study, because it included routine radiographs of the maxillary sinuses. Furthermore, the radiographical technique used here was applied consistently to all subjects and the author presumed that the internal validity of the technique would be sufficient to detect differences amongst the groups.

The modification of the adenoid–nasopharyngeal ratio, according to Qvarnberg (1981), used in the present study, pays attention to the width of the palatal airway which is the most important point in the assessment of the size of adenoids (Jeans *et al.*, 1981a; Gates *et al.*, 1989). New methods with a flexible fibrescope for examining the entire upper respiratory tract and for directly viewing the adenoids, have been introduced (Wang *et al.*, 1992). Up to the present, this is by no means routinely used in the ENT examination of adults and even less of children. It is the author's opinion that the use of a flexible nasopharyngoscope in the examination of a fair number of asymptomatic children does not seem to be a less invasive or dangerous technique than the radiographical method.

The size of the soft tissue shadow in the lateral sinus radiograph was large, and respectively, the palatal airway was small, in one third of seven-year-old children, in every fifth 10-year-old child and in every tenth 14-year-old child. Respectively, the percentage of small and medium-sized soft tissue shadow increased with age. The results are in accordance with the percentage distribution of adenoid size in a normal population reported by Pruzansky (1975) who found radiologically large adenoids in 36.6 per cent of children aged six to eight years, in 20.5 per cent of children aged eight to 10 years, and in 6.2 per cent of children aged 14 to 16 years. The results correspond with those of Fujioka *et al.* (1979) and Jeans *et al.* (1981b) about the increasing size of adenoids up to five to six years, a subsequent plateau stage and a gradual decrease in size after eight to nine years. There was no significant sex difference in the size of adenoids, although they were more often larger in boys than in girls. The same sex difference has been reported by several authors (Pruzansky, 1975; Jeans *et al.*, 1981b).

Factors related to large adenoids

According to the literature, adenoid hypertrophy should be suspected in children with chronic nasal obstruction, nasal speech, snoring, mouth breathing or rhinorrhea (Maw *et al.*, 1981; Dolen *et al.*, 1990). The hyponasality of speech was not included in the questionnaire, because it is the author's experience that nasal speech is difficult to elucidate as a symptom by the child's parents.

Recurrent snoring was highly associated with large adenoids in the present study. This is in agreement with clinical experience and previous studies (Wormald and Prescott, 1992). Also age was significantly associated with the size of adenoids. This is in agreement with Jeans *et al.* (1981b) who reported that the adenoids are largest in six to eight-year-old children. Significant nasal eosinophilia was slightly associated with the occurrence of large adenoids. An allergic child has respiratory infections more frequently than a nonallergic child. The principal stimulus for adenoid hyperplasia appears to be infectious because, also in the present study, other factors associated with large adenoids, although nonsignificant, were those related to respiratory infections. It is also well-known fact that lymphoid tissue, like adenoids, has immunological

TABLE VI

THE MEAN HEARING THRESHOLDS (dB) AND STANDARD DEVIATIONS OF THE RIGHT AND LEFT EAR IN CHILDREN WITH RADIOLOGICALLY NORMAL OR LARGE ADENOIDS

	Radiological size of adeniods									
	Right ear					Left ear				
	Normal		Large			Normal		Large		
Frequency (kHz)	Mean	SD	Mean	SD	p value	Mean	SD	Mean	SD	p value
0.125	7.5	7.2	9.3	7.3	*	6.2	6.4	8.8	7.4	***
0.25	4.6	7.2	6.3	7.1	*	2.7	6.0	5.4	7.1	***
0.5	1.7	6.8	5.2	8.2	***	1.1	5.5	5.2	8.3	***
1	0.1	6.9	2.9	8.1	***	−1.0	5.4	2.5	8.9	***
2	−0.3	6.6	1.1	7.5	*	−1.3	6.1	0.3	8.6	*
3	0.6	7.1	2.9	8.0	**	−0.8	6.8	3.4	8.9	***
4	0.6	7.6	2.7	9.7	*	0.3	7.3	3.7	10.5	***
6	6.0	8.3	7.1	10.6	NS	6.5	8.4	8.1	12.9	NS
8	4.8	8.6	6.2	10.0	NS	2.8	8.8	4.9	11.5	NS
Number of ears	398		133			398		133		

NS = Not significant; * = $p<0.05$; ** = $p<0.01$; *** = $p<0.001$.

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TABLE VII
THE MEAN VALUES OF THE EAR CANAL VOLUME, COMPLIANCE, RELATIVE GRADIENT AND MIDDLE EAR PRESSURE IN THE RIGHT AND LEFT EARS IN CHILDREN WITH NORMAL OR LARGE RADIOGRAPHICAL ADENOIDS

		Radiological size of adenoids			
		Right ear		Left ear	
Impedance audiometry		Normal (n = 398)	Large (n = 133)	Normal (n = 468)	Large (n = 63)
Ear canal	Mean	0.86	0.75	0.81	0.69
Volume (ml)	SD	0.24	0.21	0.22	0.19
Compliance (ml)	Mean	0.59	0.57	0.61	0.56
	SD	0.31	0.29	0.32	0.31
Relative gradient	Mean	0.58	0.55	0.58	0.53
	SD	0.13	0.18	0.12	0.19
Middle ear pressure (mmH_2O)	Mean	−21.2	−81.6	−17.5	−93.4
	SD	58.4	114.3	45.2	121.5

functions and, therefore, nasal eosinophilia may be related to large adenoids. However, children with a history of allergy had no tendency for a greater occurrence of large adenoids, and it is obvious that large adenoids are only associated with nasal allergy and not with other types of allergy.

Radiologically large adenoids were associated with the occurrence of secretory otitis media (SOM) and abnormal sinus X-ray and ultrasound findings in the Chi-square test but not in the logistic regression test. In the literature, large adenoids have been connected with SOM (Marttila, 1986), although contradictory results have also been presented by Maw (1983). It is possible that the connection between sinusitis and large adenoids is evident in children under seven to nine-years-old but not in older children.

Audiometric and impedance findings

Children with radiologically large adenoids had poorer hearing thresholds at all frequencies compared to control children with small/medium-sized adenoids. Analysis of variance proved a statistically significant difference ($p<0.0001$) between the audiogram curves, although the hearing thresholds differed only from 1.1 to 4.2 dB.

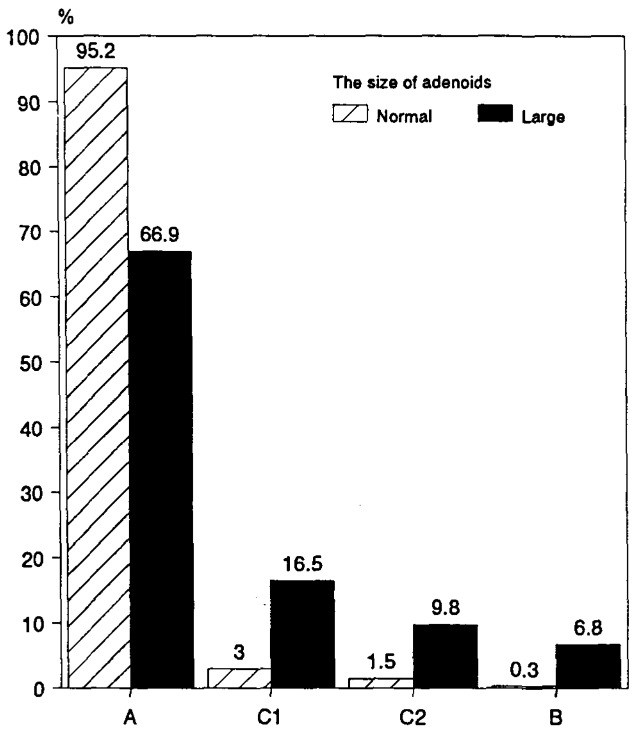

FIG. 2
The percentage distribution of A, C1, C2 and B-tympanograms according to radiologically normal or large adenoids.

Middle ear pressure values were significantly lower in children with large adenoids, and differences were 60 to 70 mmH_2O at mean values. This difference was not age-dependent because the differences were significant in both the first and fourth grades. Why does the size of adenoids not seem to have any effect on impedance findings in the oldest children? It is possible that the significance of large adenoids in the pathogenesis of negative middle ear pressure decreases with age (Marttila, 1986). Many studies have also proved that the state of middle ear pressure is dependent on age so that it is more negative in younger children (McCandless and Thomas, 1974; Smyth, 1977). Bylander *et al.* (1981) compared middle ear pressures in otoscopically healthy children aged three to 12 years with adults, and the difference was statistically highly significant (children 29.5 mmH_2O; adults 4.2 mmH_2O). In the present study the mean middle ear pressure increased and came closer to zero when the age increased from seven to 14 years.

Tuohimaa and Palva (1987) have found a highly significant difference in the middle ear pressures of children with normal ear drums, before and after adenoidectomy. The pre-operative middle ear pressure was lower the larger the adenoids were. The conclusion is that even if ear drums are healthy, large adenoids have a significant effect on middle ear pressure. This is also true in the present study because abnormal colour, position and motion of the tympanic membrane did not correlate with radiologically large adenoids in logistic regression analysis. So, it is probable that low middle ear pressure and poor hearing thresholds really are associated with large adenoids.

It has been known for a long time that the negative middle ear pressure associated with tubal dysfunction and the effusion of liquid that can ensue are likely to interfere with hearing and induce a measurable loss of acuity. Cooper *et al.* (1977) reported that the mean conductive hearing loss tended to increase with increasingly negative middle ear pressure. Moreover, acuity was significantly correlated with the tympanometrically determined pressure. Similarly, Lildholdt *et al.* (1979) reported, in a sample of seven-year-old children that a lowering of the middle ear pressure increases hearing loss. In both instances, however, the investigators found that the middle ear pressure values could not be used to predict the degree of hearing loss.

Adenoidal tissue could cause hearing impairment by mechanical or functional blockage of the eustachian tube, causing impaired ventilation of the middle ear space and negative pressure in the middle ear. This may also result in the accumulation of effusion in the middle ear cleft either because of transudation, exudation or secretion (Tos, 1984). Large adenoids were also associated with the occurrence of secretory otitis media. This may be one additional explanation, along with the negative middle ear pressure, for the impaired hearing thresholds found amongst these children.

Conclusions

The relative size of adenoids decreases with age in the population of school-aged children. The mirror examination of the nasopharynx succeeded in 91.5 per cent of children and agreement between the mirror examination and radiological adenoids was good. Large adenoids were associated with recurrent snoring, habitual mouth breathing, purulent and serous nasal secretion and tympanic membrane changes in the Chi-square test but only with snoring and age in the logistic regression analysis. Large adenoids have a deteriorating influence on middle ear pressure and hearing sensitivity, especially in younger children.

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