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Should middle ear pressure and hearing loss be evaluated prior to septoplasty? A prospective cohort study

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Ethics Committee Approval
The study was conducted with the approval of the Scientific Research Investigation Commission of Goztepe Education Research Hospital (Ethical approval number: 02/98).
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Nasal resistance is primarily caused by the deviation of the nasal septum at the level of the inferior turbinate and isthmus nasi. The pressure of the nasopharynx may decrease to less than that of the middle ear, from where the air would drain, thus creating a cavity with negative pressure. Therefore, pathological phenomena in the nasal cavity can affect the ventilation of the middle ear. In this study, we aimed to investigate how hearing is changed by septum deviation (SD) affecting middle ear pressure, and in case of hearing loss, whether there is any improvement after nasal surgery.
Methods: Sixty-seven patients were admitted to our Otorhinolaryngology clinic with nasal obstruction and hearing loss complaints, and 50 patients (≥18 years of age) with nasal congestion due to SD were included in this study. Septoplasty was performed to fifty patients and lateralization of SD was noted. Pure tone audiometric and tympanometric evaluations were performed preoperatively and postoperatively. Gain of hearing and gain of pressure after surgery were recorded, which were statistically compared between the groups.
Results: Of the 50 patients with nasal congestion and hearing impairment included in our study, 27 were male and 23 were female. The mean age of all cases was 32.08 (9.44) years, ranging between 18–56 years. Among forty-two patients with unilateral SD, thirty-seven (88%) had negative middle ear pressure. The lowest pure-tone-threshold was 1 dB, and the highest was 35 dB on the side with the deviation. On the side without SD, the lowest threshold was 8 dB, and the highest was 28 dB. Pure-tone-thresholds between 500 and 2,000 Hz were within normal range in seventy-six ears. Hearing loss was present in twenty-four ears. Postoperatively, the lowest hearing gain was 0 dB, and the highest was 15 dB on the side with the SD. On the side without SD, the lowest and highest hearing gains were 0 dB and 11 dB.
Conclusion: The negative pressure in the middle-ear due to SD may affect hearing. Hearing loss does not result from every deviation but occurs only when sufficient negative pressure is formed in the middle-ear.

Keywords: Septal deviation, Hearing loss, Middle ear

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Introduction

The physiological respiratory airway in humans passes through the nose [1]. Nasal resistance is primarily caused by deviation of the nasal septum at the level of the inferior turbinate and isthmus nasi. Nasal septal deviations due to developmental defects or trauma play a role in the formation of nasal resistance.

Ventilation of the middle ear is important for balancing the air pressure on either side of the tympanic membrane. The Eustachian tube provides ventilation of the middle ear and discharges secretions that accumulate within. The ability of the tympanic membrane to vibrate well depends on it being tensioned, with equal pressure on both sides. If the pressure on one side of the membrane exceeds the pressure on the other side, the tympanic membrane is tensioned to the side with less pressure, which prevents the formation of a normal vibration.

During swallowing in patients whose nasal cavities are obstructed for any reason, contact of the soft palate with the oropharynx can hold some air in the nasopharynx, increasing the air pressure. Therefore, in patients with septum deviation and in those whose nasal cavity is obstructed for any reason, the tube opens more easily with swallowing; however, in the second phase of swallowing, the palate is restored to its former position and the setting leads to a pressure drop in the nasopharynx. The pressure of the nasopharynx may decrease to less than that of the middle ear, from where the air would drain, thus creating a cavity with negative pressure. Therefore, pathological phenomena in the nasal cavity can affect the ventilation of the middle ear [2].

Flisberg et al. [3] applied a pressure of 680 mmH2O in the ear using the physiological environment, and when the nasal passage closed and opened during swallowing, they recorded changes in the middle ear pressure. Miller [4] performed the same test with the nasal passage closed, applying negative 400 mmH2O pressure to the ear, and determined that the pressure in the external auditory canal changed with swallowing. Brookler [5] applied negative 400 mmH2O pressure to the external auditory canal and measured residual pressure after 10 swallows, then measured the minimum positive air pressure capable of opening the tube without swallowing. All these studies showed hearing loss with negative middle ear pressure.

The aim of our study is to investigate how hearing is altered by septum deviation affecting middle ear ventilation, and if hearing loss occurs, whether there is any improvement after nasal surgery.

Materials and methods

Sixty-seven patients were admitted to the Goztepe Education and Research Hospital Otorhinolaryngology clinic within the last year with nasal obstruction and hearing loss complaints. Fifty patients over 18 years of age with nasal congestion due to septal deviation were included in the study group.

Study design and sample size

Study design has a major impact on the sample size. Descriptive studies need hundreds of subjects for acceptable confidence intervals for small effects. Experimental studies need fewer sample sizes while the cross-over designs need one-quarter of the number required compared to a control group because every subject gets the experimental treatment in a cross-over study. An evaluation study in a single group with pre-post type of design needs half the number for a similar study with a control group. For that reason, fifty patients were included the study. The definition of alpha is the probability of detecting a significant difference when the treatments are equally effective or in case of a risk of false positive findings. The alpha level used in determining the sample size in most academic research studies are either 0.05 or 0.01. The lower the alpha level, the larger the sample size. For example, a study with alpha level of 0.01 requires more subjects when compared to a study with alpha level of 0.05 for similar outcome variable. So, we used *P*-value as <0.05 to determine statistical significance. The difference between two groups in our study was explored in terms of estimate of effect, appropriate confidence interval, and *P*-value. The confidence interval indicates the likely range of values for the true effect in a population while *P* value determines how likely it is that the observed effect in the sample is due to chance. A related quantity is the statistical power of the study, which is the probability of detecting a predefined clinical significance. The ideal study is the one with high power. This means that the study has a high chance of detecting a difference between groups if it exists. Consequently, if the study demonstrates no difference between the groups, the researcher can be confident in concluding that none exists. The ideal power for any study is 80%, the same as ours.

The study was conducted with the approval of the Scientific Research Investigation Commission of Goztepe Education Research Hospital (Ethical approval number: 02/98). Informed consent was obtained from the patients. Patients with a history of allergic rhinitis or other causes of nasal congestion, who needed nasal plastic reconstruction, or who had sleep apnea, deformity of the columella, alar collapse, adenoid hypertrophy, acute or chronic sinusitis, nasal vestibular pathologies, a history of acoustic trauma, anamnesis of previously treated otitis media, and otitis media sequela in the otoscopic examination as well as patients with a history of using ototoxic drugs and those who had previously undergone nasal surgery were excluded from the study.

Nasal examination

The causes of nasal obstruction were evaluated through anterior and posterior rhinoscopic examination of the patients. Cotton pledgets with pantocaine (1% tetracaine-Hcl) were used to examine the nasal passage. The lateralization of the nasal septum and its localization were noted. The pharyngeal orifice of the Eustachian tube was examined. In the otoscopic examination, the shape of the auricle, the anatomical and structural differences between the external auditory canals, the appearance of the tympanic membrane, mobility, and perforation were examined. The patency of the Eustachian tube was checked using the Valsalva test. Rinne, Weber, and Schwabach tests were performed using 512 frequency diapasons.

Audiometric evaluation

Audiometric evaluations were performed using interacoustics AC3 and Madsen OE822 clinical audiometer devices. Pure-tone averages (PTA) of thresholds at 500, 1,000, and 2,000 Hz frequencies were measured in both ears.

Tympanometric measurements were made using interacoustic impedance audiometer AZ7 and XYT recorder AG3 devices to obtain tympanogram curves. During the acoustic impedance tests, patients were instructed not to cough or sniff. Measurement was performed by applying positive pressure to the middle ear. Patients with normal pure-tone thresholds at speech frequencies between 0 and 26 dB and middle ear pressures between +25 and -25 mmH2O were considered the normal group. The Student's-t test was used to compare groups.

Surgical procedure

In septoplasty operation, submucosal resection under local anesthesia was performed using the Killian method to correct patients' septal deviations. The anterior pack inserted into the nose was removed after 48 hours. Patients were given amoxicillin for five days and paracetamol as an analgesic. Postoperative audiometric and tympanometric measurements were conducted on the 21st day following the operation in accordance with the literature [6].

Statistical analysis

One of the most important tests within the branch of inferential statistics is the Student's t-test. The Student's t-test for two samples is used to test whether two groups are different in terms of a quantitative variable, based on the comparison of two samples drawn from these two groups. Our groups' sizes were sufficient for statistical analysis, which was performed using SPSS for Windows version 21 (IBM SPSS Inc., Chicago, IL, USA). The minimal level of significance was fixed at *P*-value ≤0.05.

Results

Of the 50 patients with nasal congestion and hearing impairment included in our study group, 27 were male and 23 were female. The mean age of all cases was 32.08 (9.44) years with an age range of 18–56 years. Decreased tympanic membrane tension was detected in 72 (72%) of 100 ears with a pneumatic otoscope. Eustachian tube permeability, detected with a Valsalva test, was within the normal range in 57 (57%) of 100 ears.

In all patients, bone conduction thresholds were between 0 and 20 dB, which was within normal range. In diapason tests, the Rinne test was positive in 79 ears. The Weber test was not lateralized in 79 ears; in 21 ears, the test was lateralized to the right or the left. The Schwabach test results were within the normal range in 79 ears and extended in 21 ears.

We found that 23 of 42 patients with unilateral septal deviation had a right deviation, and 19 had a left deviation. In eight patients, bilateral septal deviation was present. In 42 patients with unilateral septal deviation, the middle ear pressure on the side without the deviation ranged between 50 mmH2O-175 mmH2O. Of the 42 patients with unilateral septal deviation, 37 (88%) had negative middle ear pressure. Middle ear pressures in eight patients with bilateral septal deviation were negative in both ears. The lowest pure tone thresholds were 10 dB, and the highest were 35 dB on the side with deviation. On the side without septum deviation, the lowest threshold was 8 dB, and the highest threshold was 28 dB. Pure tone thresholds between 500 and 2,000 Hz were within normal range in 76 ears. Hearing loss was present in 24 ears.

In the postoperative period, the lowest hearing gain was 0 dB, and the highest was 15 dB on the side with the septum deviation. On the side without a deviated septum, the lowest and highest hearing gain values were 0 dB and 11 dB, respectively. The preoperative and postoperative period hearing gains in 12 (12%) ears were similar (Table 1) (*P*=0.064).

Table 1: Pure tone audiometry results in preoperative and postoperative period and gains of hearing in patients after surgery

Patient no	Age/Sex	Deviation	Pure Tone Audiometry (dB)				Gain of Hearing	
			Preoperative		Postoperative			
			(R)	(L)	(R)	(L)	(R)	(L)
1	36/M	Right	25	20	10	10	15	10
2	21/M	Bilateral	23	1 8	15	10	8	8
3	18/M	Left	28	24	17	1 1	11	13
4	24/F	Left	18	20	16	14	2	6
5	33/F	Right	31	17	25	13	6	4
6	46/M	Right	27	24	20	16	7	8
7	23/F	Bilateral	25	23	16	16	9	7
8	27/F	Left	18	21	14	12	4	9
9	18/F	Left	15	10	14	10	1	0
10	29/M	Right	14	10	11	8	3	2
11	37/F	Right	16	1 0	10	10	6	0
12	19/M	Left	18	12	8	7	10	5
13	24/M	Left	13	27	10	13	3	14
14	18/F	Right	15	1 1	6	6	9	5
15	30/M	Bilateral	30	18	21	12	9	6
16	24/F	Right	12	8	12	8	0	0
17	18/F	Left	15	20	15	I5	0	5
18	31/M	Right	21	13	14	1 1	7	2
19	27/F	Bilateral	16	21	10	14	6	7
20	48/M	Right	17	14	10	12	7	2
21	32/F	Right	19	14	15	10	4	5
22	34/M	Bilateral	21	16	16	1 5	5	1
23	41/M	Right	35	17	23	14	12	3
24	46/F	Left	13	24	10	1 4	3	10
25	31/M	Right	18	11	13	9	5	2
26	37/M	Bilateral	15	17	15	17	0	0
27	51/F	Right	18	21	14	19	4	2
28	38/M	Right	30	15	21	13	9	2
29	29/M	Left	14	18	10	10	4	8
30	31/M	Right	21	13	13	8	8	5
31	56/M	Left	10	18	10	12	0	6
32	38/F	Left	17	26	15	18	2	8
33	30/M	Right	16	11	11	7	5	4
34	45/M	Left	18	1 1	14	7	4	4
35	33/F	Left	8	17	6	10	2	7
36	27/M	Right	19	16	16	16	3	0
37	29/F	Left	12	14	12	14	0	0
38	34/F	Right	26	13	18	10	8	3
39	34/F	Right	12	10	8	8	4	2
40	31/M	Bilateral	24	14	20	10	4	4
41	29/F	Left	14	18	12	13	2	5
42	34/M	Right	20	16	14	10	6	6
43	27/F	Left	13	18	11	12	2	6
44	56/M	Bilateral	21	12	15	10	6	2
45	34/F	Right	18	14	14	14	4	0
46	39/M	Left	14	12	11	8	3	4
47	24/F	Right	18	14	12	9	6	5
48	26/M	Left	17	14	12	10	5	4
49	39/F	Right	17	11	13	8	4	3
50	18/M	Left	14	20	10	12	4	8

R: Right, L: Left.

The otoscopic examination results did not differ from preoperative findings. The results of the diapason tests performed in the postoperative period were as follows: Rinne was positive in 88 ears and negative in 12 ears; Weber was not lateralized in 88 ears and lateralized in 12 ears; Schwabach detected normal ranges in 86 ears and extended in 14 ears; the Valsalva test showed that the tubal patency in 81 of 100 ears in the postoperative period was normal (positive). In 19 ears, tubal patency was impaired (negative). When the middle ear pressure gains were examined, the lowest pressure gain obtained on the side of the septum deviation was 0 mmH2O, and the highest pressure gain was 150 mmH2O. On the side where there was no deviated septum, the lowest and pressure gains were 0 mmH2O and 75 mmH2O, respectively. There was no pressure gain in 13 of 100 ears (Table 2) (*P*=0.058).

Table 2: Tympanometry results in preoperative and postoperative period and gains of pressure in patients after surgery.

Patient no	Age/sex	Deviation	Pressure of Middle Ear (mmH2O)				Gain of Pressure	
			Preoperative		Postoperative			
			(R)	(L)	(R)	(L)	(R)	(L)
1	36/M	Right	-75	-1 00	-50	-50	25	50
2	21/M	Bilateral	- 1 00	-125	-25	0	75	12
3	18/M	Left	-150	-200	-75	-50	75	1 5
4	24/F	Left	-75	-50	-50	-25	25	25
5	33/F	Right	-150	-100	-75	-75	75	25
6	46/M	Right	-100	-100	-50	-75	50	25
7	23/F	Bilateral	-175	-150	-25	-50	150	10
8	27/F	Left	-100	-200	-100	- 150	0	50
9	18/F	Left	-50	50	-25	-25	25	25
10	29/M	Right	-150	-100	0	-25	1 50	75
11	37/F	Right	-50	-25	0	0	50	25
12	19/M	Left	-100	-125	-50	-50	50	75
13	24/M	Left	-50	-125	0	25	50	150
14	18/F	Right	-75	-50	25	25	100	75
15	30/M	Bilateral	-100	-50	0	0	100	50
16	24/F	Right	-75	-75	-50	-75	25	0
17	18/F	Left	-50	- 150	-25	-50	25	100
18	31/M	Right	100	50	50	25	50	25
19	27/F	Bilateral	-150	-125	-75	-75	75	50
20	48/M	Right	-100	-50	-25	0	75	50
21	32/F	Right	25	25	25	25	0	0
22	34/M	Bilateral	-150	-100	-75	-50	75	50
23	41/M	Right	-200	-150	-100	-75	100	75
24	46/F	Left	25	50	25	25	0	25
25	31/M	Right	-25	-25	-25	-25	0	0
26	37/M	Bilateral	-150	-100	-125	-100	25	0
27	51/F	Right	-100	-125	-75	-100	25	25
28	38/M	Right	-50	-75	0	-25	50	50
29	29/M	Left	25	25	0	0	25	25
30	31/M	Right	-50	-50	0	-25	50	25
31	56/M	Left	-125	-175	-100	-100	25	75
32	38/F	Left	-150	-175	-100	-100	50	75
33	30/M	Right	-100	-75	-50	-50	50	25
34	45/M	Left	-175	-150	-100	- 100	75	50
35	33/F	Left	-50	-50	0	0	50	50
36	27/M	Right	-50	-75	-25	-75	25	0
37	29/F	Left	-125	-100	-50	-50	75	50
38	34/F	Right	-100	-50	-75	-5O	25	0
39	34/F	Right	- 175	-100	-100	-75	75	25
40	31/M	Bilateral	-200	-150	-150	-75	50	75
41	29/F	Left	25	25	25	25	0	0
42	34/M	Right	-150	-100	-75	-50	75	50
43	27/F	Left	-75	-100	-50	-50	25	50
44	56/M	Bilateral	-100	-50	-50	0	50	50
45	34/F	Right	-75	-50	-50	-25	25	25
46	39/M	Left	-100	-150	-50	-50	50	100
47	24/F	Right	-75	-50	-50	-50	25	0
48	26/M	Left	-100	-125	-50	-75	50	50
49	39/F	Right	-75	-75	-25	-50	50	25
50	18/M	Left	-150	-200	-75	-100	75	100

Discussion

Nasal septal deviations narrow the respiratory tract, causing various complications in neighboring structures. The role of septal deviations in pathologies of the middle ear is undisputed. However, opinions differ about the frequency and importance of these middle ear complications among other upper respiratory complications [7].

As a result of nasal septal deviation, breathing through the nose is disturbed, the lumen of the Eustachian tube narrows, and the ventilation of the middle ear is disrupted. Insufficiency in the tubal canal creates negative pressure in the middle ear, which causes hearing loss before forming a collection of fluids of a transudate character in the middle ear [3]. In studies on the prevention of this fluid formation, it has been proven that negative pressure formed in the middle ear disrupts hearing. Hearing is especially decreased in speech frequencies, while no loss was detected in frequencies greater than 2,000 Hz [7].

In the literature, the effects of air pressure on the middle ear have been investigated, and a direct relationship was found between negative pressure and hearing loss. It is known that nasal septal deviations disrupt the ventilation of the middle ear. In our study, we investigated the effect of air pressure on hearing during the preoperative period and found that the middle ear air pressure on the side with nasal septal deviation was negative in 90% of cases [3]. Negative pressure values slightly reduced hearing in 24% of cases (21–35dB). Hearing was unaffected in 76% of cases. Hearing loss was the conductive type. In our study, hearing loss rate on the side with nasal septal deviation was 24%, and negative pressure in the middle ear was 90%.

Negative pressure and hearing loss levels were not in complete harmony. Negative pressure in the middle ear may not occur in all nasal septal deviations [8, 9]. In our study, hearing gain occurred in 88% of patients by the 21st postoperative day, but a hearing gain of <10dB occurred in only seven ears. We found that postoperative hearing gain of <10dB occurred in 18 ears by the 60th postoperative day. On the 90th postoperative day, a hearing gain of <10dB was detected in 25 ears. Thus, postoperative recovery in hearing occurs over time [3]. Also Kaya et al. [10] showed that septoplasty may have a beneficial effect on middle ear ventilation and Eustachian Tube in their study. Duran et al. [11] found that approximately 30% improvement occurs in the middle ear pressure after septoplasty. In contrast, Eyigör et al. [12] described that the success of septoplasty operation does not affect the ventilation and pressure of the middle ear significantly.

Rhinosinusitis can be induced by impaired ventilation and drainage in patients with a deviated nasal septum (especially those with a high deviation) due to a moved middle turbinate under consistent pressure [9]. Tubal collapse due to septum deviation affects both ears to varying degrees. In the postoperative period, hearing loss on the side with nasal septal deviation and gains of air pressure in the middle ear are correlated with the numerical values on the side without septum deviation. The cause of unilateral aural fullness is usually same-side obstructions in the nasal cavity. Negative pressure affecting the ear is the cause of the nasal congestion, and sometimes it can bilaterally affect the tubal orifice. With this mechanism, inflammation and edema in the nasal cavity drained by peritubal lymphatics leads to tubal obstruction and causes effusion of the middle ear. As a result of nasal obstruction, ciliary activity is disturbed. With the lymphatic plexus pathway on the side with nasal obstruction, the contralateral nasopharynx may also be affected [13]. Negative pressure resulting from nasal septal deviation can affect both ears over time.

Limitation

One minor limitation to this study might be the limited number of participants. Also, a major limitation of our study is lack of evaluations of allergic rhinitis with laboratory tests.

Conclusion

The negative pressure in the middle ear occurring because of nasal septal deviation may affect hearing. On the other hand, hearing loss does not result from every deviation, but occurs only when sufficient negative pressure is formed in the middle ear. The tympanometric findings that we detected in our study showed that middle ear pressure was significantly affected in patients with deviation but returned to normal values during the postoperative period. In most patients in the postoperative period, there was an improvement in hearing over time.

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