



Original Article

Should Nasal Function be Considered Prior to Tympanoplasty?

Metin Yüksel Akyıldız, Ömer Afşın Özmen, Uygur Levent Demir, Fikret Kasapoğlu, Hamdi Hakan Coşkun, Oğuz İbrahim Basut, Deniz Sığırlı

Department of Otolaryngology, Uludağ University School of Medicine, Bursa, Turkey (ÖAÖ, ULD, FK, HHC, OİB)
Department of Biostatistics, Uludağ University School of Medicine, Bursa, Turkey (DS)
Department of Otolaryngology, Darende State Hospital, Malatya, Turkey (MYA)

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OBJECTIVE: To evaluate the association between nasal airway function and Eustachian tube (ET) functions and their impact on tympanoplasty in patients with chronic suppurative otitis media (CSOM).

MATERIALS and METHODS: The study group (CSOM group) consisted of 33 patients scheduled to undergo tympanoplasty for CSOM. Two control groups were formed: a nasal septal deviation (NSD) group of 25 patients scheduled to undergo nasal surgery for NSD, and a control group of 25 healthy individuals with no otologic or rhinologic symptoms. ET functions were assessed tympanometrically with automatic Williams test (ETF1) and modified pressure equalization inflation-deflation test (ETF2) and nasal functions were analyzed using acoustic rhinometry and rhinomanometry. The patients in the CSOM group underwent tympanoplasty, and tests were repeated at the end of the 3rd postoperative month.

RESULTS: Both acoustic rhinometry and rhinomanometry revealed similar nasal function in the CSOM and NSD groups, which was inferior to that of the control group. The CSOM group had the worst ET function. Dysfunctional ETs in the CSOM group improved at 3 months postsurgery, and all groups had a similar outcome regarding ET functions. The outcome of ear surgery was not affected by nasal function, and the graft take rate was 90%.

CONCLUSION: Patients with NSD had generally poor ET function; however, this did not affect the outcomes of tympanoplasty. The preoperative ET function results were inconsistent with the results following tympanoplasty; therefore, they were not predictive of need for septoplasty. Thus, we do not universally recommend surgical correction of NSD prior to ear surgery; however, this decision should be made on an individual basis.

KEYWORDS: Nasal septum, nasal airway obstruction, Eustachian tube, tympanoplasty

INTRODUCTION

The role of nasal obstruction in the pathophysiology of ear diseases and tympanoplasty outcomes is a source of debate. Among several factors proposed as underlying the pathogenesis of chronic suppurative otitis media (CSOM), Eustachian tube (ET) dysfunction holds a central place^[1]. Nasal obstruction has been identified as a potential cause of ET dysfunction along with many other factors, such as allergic rhinitis, laryngopharyngeal reflux, cleft palate, adenoid hypertrophy, mucosal diseases of nasopharynx, and prior radiotherapy^[2-5].

As an air-filled cavity, the middle ear depends on a properly functioning ventilation system to regulate air pressure. This ventilation system comprises intact neural control mechanisms, an elastic tympanic membrane, well-pneumatized mastoid air cells, gas exchange balance between middle ear mucosa and capillary circulation, and a bi-directionally functioning ET^[6]. The ET plays a crucial role in regulating the middle ear pressure by equalizing the middle ear pressure and atmospheric pressure. Nasal pathologies have been shown to worsen the middle ear ventilation via a negative influence on airflow parameters. Nasal obstruction has been reported to increase nasal resistance to airflow, thereby changing the opening pressure threshold of the ET^[7-12].

As a contributor to ET dysfunction, nasal obstruction has been identified as reducing the success rate of tympanoplasty. Therefore, some authors have proposed performing nasal surgery prior to tympanoplasty in patients with coexisting nasal septal deviation (NSD)^[4].

Corresponding Address: Ömer Afşın Özmen E-mail: oaozmen@yahoo.com

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In this prospective controlled study, using objective tests, we aimed to evaluate the association between nasal airway function and ET function and its impact on tympanoplasty in patients with CSOM.

MATERIALS and METHODS

This prospective and controlled study was conducted at Uludağ University Hospital between February 2012 and February 2013. The ethics committee of the Uludağ University Medical School approved the study. Signed informed consent was obtained from all subjects.

One study group and two control groups were formed. The study group comprised 33 otherwise healthy patients who were scheduled for primary tympanoplasty and diagnosed with tubotympanic CSOM (CSOM group). One of the control groups was a positive control consisting of 25 otherwise healthy patients who were scheduled to undergo nasal surgery due to NSD (NSD group). The criteria for the patients in the NSD group included the absence of otologic signs or symptoms. The other control group was a negative control consisting of 25 healthy adults with neither rhinologic nor otologic symptoms or signs (control group).

To avoid developmental issues related to ET and otitis media, an age limit was established to exclude patients younger than 14 years. No history of upper respiratory tract infections in the previous month was an additional criterion for the study. The patients were also questioned and examined to rule out any systemic, syndromic, or otolaryngologic diseases, including laryngopharyngeal reflux and allergic rhinitis, or previous otolaryngologic surgery.

Exclusion criteria were unexpected operative findings (retraction pockets, cholesteatoma, etc.) that did not meet the inclusion criteria and an inability to complete all required examinations.

All subjects were analyzed objectively for nasal airway function and ET function. The hearing thresholds of all subjects were also measured audiotically. Patients in the CSOM group were re-tested for ET functions and hearing thresholds 3 months following surgery.

The patency of the nasal airway was evaluated objectively using acoustic rhinometry and anterior rhinomanometry (RhinoScan/Rhinometrics® SRE2000, Denmark and RhinoStream v.2.1, RhinoMetrics® SRE2000, Denmark). For the acoustic rhinometry, no decongestants were used prior to the test, and the measurements were repeated until three optimal curves were observed. The patients were asked to hold their breath after the nasal adaptor was placed at the end of the nostril. Each nasal passage was tested separately. Minimum cross-sectional areas (MCA1 and MCA2) were considered the main objective outcomes. The other objective test was anterior rhinomanometry, which measured nasal airway resistance at 150 Pa. In this test, the patients were asked to breathe through one nostril while the other nostril was closed with pressure probe. The nasal resistance (NR) of each nasal passage was obtained. Then, the total nasal resistance (TNR) was analyzed using the following formula: $1/\text{total nasal resistance} = 1/\text{right nasal resistance} + 1/\text{left nasal resistance}$ during inspiration.

For MCA1, MCA2, and NR, which were obtained for both sides, we considered the side with smaller MCA1 and MCA2 values and larger NR values the narrow side, and the side with the converse results as the wide side for analysis in each group.

Eustachian tube function was analyzed with tympanometry (Impedance Audiometer AZ 26, Interacoustics, Assens, Denmark). Ears with a perforated tympanic membrane were assessed using a modified pressure equalization inflation-deflation test (ETF2)^[13]. In the ETF2 test, the probe was placed in the external ear canal, and pressure changes in the middle ear were recorded, while the patient was asked to perform the Toynbee maneuver three times in 80 seconds. For each maneuver, the opening (O1, O2, O3) and closing (C1, C2, C3) pressures were measured. ET function was considered normal if any compensation of both positive and negative pressures was achieved. Failure to compensate any of the pressures was defined as ET dysfunction. In ears with an intact tympanic membrane, tube function was assessed with automatic Williams test (ETF1). This test was performed by measuring the basal middle ear pressure at rest (P1) during the Toynbee maneuver (P2) and the Valsalva maneuver (P3) with tympanometry. A pressure difference between P1 and P2 greater than 10 daPa and a difference between Pmax and Pmin greater than 15 daPa were considered normal function.

For the hearing evaluation, the mean air and bone conduction thresholds were recorded (GSI 61 clinical audiometer, Grason-Stadler-VI-ASYS Healthcare, Madison, Wisconsin, USA), and air bone gaps were calculated at 0.5, 1, 2, and 4 kHz.

Statistical Analysis

Statistical analysis was carried out using Statistical Package for Social Sciences version 20 (IBM Corp.; Armonk, NY, USA). Comparisons of two independent groups were performed using the Mann-Whitney U test, and the Kruskal-Wallis test was used to compare more than two independent groups. Two dependent groups were compared using the Wilcoxon test. Continuous variables are presented as median (minimum-maximum) or mean (\pm standard deviation) according to their distribution, and discrete variables are presented as (n) and (%). Independent discrete variables were analyzed with Pearson's chi-square and Fisher's exact chi-square tests. Dependent discrete variables were analyzed with the McNemar test. $p < 0.05$ was set as the level of statistical significance.

Results

All but three patients enrolled in the study completed the study. Three patients in the CSOM group were excluded from the study because of the intraoperative discovery of retraction pockets, which led to a change in the diagnosis. There was no difference between the groups regarding age and gender (Table 1).

In the CSOM group, one half of the patients had intact tympanic membranes in the contralateral ear. The other half had bilateral tympanic membrane perforation. The number of patients having surgery on either side was the same. All patients underwent tympanoplasty without atticotomy or mastoidectomy. Fascia obtained

from the temporal muscle was used in 21 patients. Tragal cartilage was chosen as the graft material for 5 patients, and both materials were used in 4 patients according to the surgeon's preference. Nasal examinations of 17 patients in the CSOM group revealed an obstructive NSD.

The assessment of nasal airway functions revealed significant differences between the 3 groups in all the test parameters measured in the narrow side of the nose. A subgroup analysis found differences

Table 1. Demographic distribution of groups

	Control group (n=25)	CSOM group (n=30)	NSD group (n=25)	p
Age (years) ^a	27 (24-67)	29 (15-59)	33 (15-76)	0.2
Sex ^b	Female	8 (32)	12 (40)	0.216
	Male	17 (68)	18 (60)	

CSOM: chronic suppurative otitis media; NSD: nasal septum deviation

^amedian (minimum-maximum); ^bn (%)

Table 2. Comparison of nasal airway functions of the groups

	Control group (n=25)	CSOM group (n=30)	NSD group (n=25)	p
NMCA ₁ ^{a,b}	0.54 (0.18-0.87)	0.41 (0.05-0.75)	0.41 (0.05-0.77)	0.048*
WMCA ₁ ^{a,b}	0.64 (0.31-1.03)	0.64 (0.24-0.98)	0.53 (0.21-1.01)	0.110
NMCA ₂ ^{a,b}	0.45 (0.20-1.09)	0.35 (0.05-0.79)	0.40 (0.05-1.12)	0.081**
WMCA ₂ ^{a,b}	0.73 (0.25-1.24)	0.71 (0.21-1.04)	0.64 (0.12-1.90)	0.776
NNAR ^{a,c}	0.70 (0.19-1.20)	0.98 (0.36-4.72)	1.07 (0.41-2.64)	<0.001*
WNAR ^{a,c}	0.29 (0.11-0.90)	0.53 (0.30-1.05)	0.65 (0.21-1.21)	0.002*
TNAR ^{a,c}	0.20 (0.04-0.85)	0.33 (0.16-0.76)	0.41 (0.17-0.65)	0.001*
Dual group comparisons				
	Control-CSOM	Contro-NSD	CSOM-NSD	p
NMCA ₁	0.132	0.017*	0.257	(p)
NMCA ₂	0.058**	0.046*	0.806	
NNAR	0.003*	<0.001*	0.302	
WNAR	0.007*	0.002*	0.094	
TNAR	0.004*	0.001*	0.181	

CSOM: chronic suppurative otitis media; NSD: nasal septum deviation; NMCA: minimal cross-sectional area of the narrow side; WMCA: minimal cross-sectional area of the wide side; NNAR: nasal airway resistance of the narrow side; WNAR: nasal airway resistance of the wide side; TNAR: total nasal airway resistance

*statistically significant (p<0.05), **close to statistical significance.

^amedian (min-max), ^bcm², ^cPa/cm³/sec

Table 3. Eustachian tube functions on ear basis according to groups. Study group was presented according operated/non-operated side and preoperative/postoperative state

Eustachian Tube Function	CSOM Group (n=60)					
	Operated side (n=30)		Non-operated side (n=30)	NSD Group (n=50)	Control Group (n=50)	
	Preoperative	Postoperative				
Intact TM (ETF1)	Normal	-	22	11	34	43
	Dysfunction	-	5	4	16	7
Perforated TM (ETF2)	Normal	11	3	3	-	-
	Dysfunction	19	0	12	-	-

CSOM: chronic suppurative otitis media; NSD: nasal septum deviation; TM: tympanic membrane; ETF1: automatic Williams test; ETF2: modified pressure equalization inflation-deflation test

between the NSD and control groups in both acoustic rhinometry and rhinomanometry. Additionally, the rhinomanometric measurements of the CSOM group were significantly worse than those of the controls (Table 2).

In the CSOM group, only 25 out of 60 ETs had normal function (42%), which was lower than the proportions for the NSD and control groups (68% and 86%, respectively; p<0.001); the NSD group also had more frequent ET dysfunction than the control group (p=0.033; Table 3).

In the postoperative 3rd month analysis of the CSOM patients, the graft was intact in all but 3 cases, resulting in an overall graft take rate of 90%. Audiologically, bone conduction thresholds were similar to preoperative levels (p=0.126), whereas air bone gaps were improved significantly (p<0.001), resulting in an ABG below 10 dB in 18 patients (60%) and below 20 dB in 27 patients (90%; Table 4).

Interestingly, the rate of normally functioning ETs increased to 65% in the controls at postoperative 3 months (Table 3). When only operated ears were examined, the normal ET rate increased from 37% to 83% during the postoperative period. Two patients with graft failure had dysfunctional ETs preoperatively; however, all 3 patients with graft failures were found to have normal function during the postoperative period. The CSOM group continued to have significantly worse ET functions than the control group during the postoperative period (p=0.012); however, the CSOM and NSD groups became comparable. When only the operated ears were considered, the CSOM group and the control group had similar ET functions during the postoperative period (p=0.074). To prevent bias regarding ETF1 and ETF2, the ET functions of the groups were compared using data from the patients who were only tested with the ETF1 test. The ET functions of the CSOM group during the postoperative period and those of the NSD and control groups were normal in 79%, 68%, and 86% of cases, respectively, which was similar for all groups (p=0.096).

Nasal functions were analyzed according to ET function. Although none of the parameters were significant, TNR and nasal resistance in the narrow side of the nose and MCA2 were worse in patients with dysfunction in at least one ET compared with patients with bilateral normal ET function. These differences were close to the level of significance (Table 5). During the postoperative period, we did not find any difference in nasal functions according to ET function. There was no correlation between nasal airway function and ET function.

Table 4. Audiological outcomes in CSOM group

	BCT*	ACT*	ABG*
Preoperative	12 (0-36)	38 (6-75)	27 (8-46)
Postop 3 month	10 (0-33)	22 (6-73)	10 (2-41)

CSOM: chronic suppurative otitis media; BCT: bone conduction threshold; ACT: air conduction threshold; ABG: air bone gap; postop: postoperative

*median (minimum-maximum)

Table 5. Nasal functions of patients according to Eustachian tube function

	Normal	Dysfunctional	p
NMCA ₁ ^{a,b}	0.45 (0.1–0.77)	0.41 (0.05-0.87)	0.427
WMCA ₁ ^{a,b}	0.64 (0.21-1.03)	0.61 (0.24-0.98)	0.743
NMCA ₂ ^{a,b}	0.44 (0.06-1.12)	0.38 (0.05-1.09)	0.081**
WMCA ₂ ^{a,b}	0.71 (0.12-1.90)	0.71 (0.19-1.84)	0.444
NNAR ^{a,c}	0.74 (0.19-2.64)	1.00 (0.22-4.72)	0.056**
WNAR ^{a,c}	0.50 (0.11-0.91)	0.59 (0.19-1.21)	0.105
TNAR ^{a,c}	0.27 (0.04-0.85)	0.36 (0.10-0.76)	0.056**

NMCA: minimal cross-sectional area of the narrow side; WMCA: minimal cross-sectional area of the wide side; NNAR: nasal airway resistance of the narrow side; WNAR: nasal airway resistance of the wide side; TNAR: total nasal airway resistance

**close to statistical significance.

^amedian (min-max), ^bcm², ^cPa/cm³/sec

DISCUSSION

Few available studies have evaluated nasal function in patients with CSOM. Güçlü et al. [14] showed higher right- and left-sided NRs and TNR in CSOM patients compared with controls, but there was no difference in acoustic rhinometry. Similarly, we found that NRs and TNR were significantly higher in the CSOM patients compared with the control subjects. Moreover, the differences in MCA2 values were also smaller in CSOM patients, which was close to significance. We analyzed the results according to the wide or narrow side of the nose, rather than the right or left side, which we considered more logical. We compared the CSOM patients not only with healthy controls but also with NSD patients. The nasal functions of the CSOM group were found to be between those of the control group and the NSD group (positive control). This was not a surprise considering that half of the patients were found to have NSD on physical examination. Although our control group did not represent the general population, NSD has been reported to be more prevalent in CSOM patients [15].

The link between NSD and CSOM is thought to be ET. How nasal obstructive pathology causes ET dysfunction is not fully clear, but there are many theories [16]. Obstructive pathologies such as septal deviation, turbinate hypertrophy, or nasal polyposis increase the nasal resistance to air. According to the Bernoulli principle, when air flows through narrow spaces, the velocity of the flow increases, and laminar flow turns into turbulent flow. Turbulent and fast airflow leads to high negative pressure at the nasopharynx, which may cause ET dysfunction. Another suggested theory regarding the pathogenesis of CSOM is the sniff theory: Due to an inadequate nasal airway, even greater negative pressure is reached during inspiration, which leads to the aspiration of air from the middle ear. The Toynbee phenomenon also provides a possible explanation of ET dysfunction by causing abnormal pressure fluctuations in the nasopharynx during swallowing in cases of blocked nasal passages. Mucosal inflammation, which affects both the nose and the ET, would be part of the

pathogenesis. As an extension of the respiratory system, the mucosa of the ET is not spared from inflammatory pathologies that affect the nasal mucosa. Watson [17] mentions that not only structural factors such as septal deviation, but also nasal mucosal edema play a role in the interrelation of CSOM and nasal obstruction.

More frequently, deviation of the nasal septum has been associated with ET dysfunction [4,9,12]. Moreover, nasal surgery worsens ET function [4,9]. The improvement of ET function and middle ear pressure with nasal surgery was reported in some studies [4,10,12]. As a result, Salvinelli et al. [4] proposed nasal surgery prior to tympanoplasty. However, other studies yielded contradictory results [9,18]. Accordingly, Maier and Krebs [9] stated that the decision to perform nasal surgery prior to tympanoplasty should be restricted to those with poor ET functions and severe nasal problems.

The association between ET functions and the success of tympanoplasty was evaluated in previous studies. [19-22] Although ET functions were deemed important for tympanoplasty outcomes and were recommended to be considered prior to surgery [19,20,22], this was not supported in all studies [23]. An explanation for this discrepancy may be the inadequacy of ET function tests. Complete obstruction of the ET that did not even allow dye or saccharine to pass would clearly result in failure of the ear operation, but in case of partial dysfunction, the interaction was less clear [20,21]. There were 3 graft failures in the present study, and all 3 had normal ET function postoperatively. ET function was not found to affect tympanoplasty outcomes in terms of either the graft take rate or the audiological results.

We found significantly worse ET functions in the CSOM group; however, with the same nasal anatomy, the patients' ET functions were improved in the postoperative period. This improvement may have resulted from the tympanoplasty operation. Tos [24] reported that ET functions, assessed using the Valsalva maneuver, improved from 64% to 87% after tympanoplasty. This improvement was explained by the removal of the mucous membranes, sclerotic plaques and adhesions at the middle ear orifice of the ET and the suppression of mucosal inflammation. Another possible cause of the difference in ET functions is the discordance between the ETF1 and ETF2 tests. However, the recovery of ET functions was also established in patients with graft failure. In either case, the preoperative assessment of ET functions was not consistent with the postoperative diagnosis. Thus, the use of preoperative ET function to determine whether to perform nasal surgery would be misleading.

Another problem with the studies on this subject was that all of them provided indirect evidence. The best evidence for determining the need to perform nasal surgery prior to tympanoplasty would come from a prospective study comparing the tympanoplasty results of patients who had undergone prior nasal surgery with those who had not. We do not agree with the current information supporting a general recommendation of septoplasty before tympanoplasty.

There was a tendency for poor ET functions in patients with NSD; however, it did not affect tympanoplasty outcomes. Moreover, the ET functions of the CSOM group became similar to those of the control groups postoperatively. Preoperative ETF results were inconsistent with the results following tympanoplasty; therefore, it would be

misleading to use them to determine the indication for septoplasty. Thus, we do not universally recommend the surgical correction of NSD prior to ear surgery; however, this decision should be made on an individual basis.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Uludağ University School of Medicine.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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