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Original Article

Prognostic Value of Acoustic Rhinometry and Rhinomanometry in Tympanoplasty Surgery

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OBJECTIVE: Chronic otitis media (COM) is a disorder characterized by perforation of the eardrum and hearing loss following chronic inflammation of the middle ear cavity, ossicules, and mastoid cells. Eustachian dysfunction plays an important role in COM etiopathogenesis and postoperative prognosis. The determinants of postoperative prognosis are still being researched. This study aimed to research the prognostic value of acoustic rhinometry (ARM) and rhinomanometry (RMM) in COM surgery in terms of eradication of the infection after operation, graft success, and hearing gain in operated cases.

MATERIALS and METHODS: This study included 58 patients who underwent surgery with a diagnosis of COM. Patients were assessed in terms of age, gender, COM type, treatment methods used, eradication of infection, graft success, and hearing gain. ARM and RMM measurements were performed in the preoperative period. ARM and RMM values were statistically compared in terms of the existence of postoperative infection, graft success, and hearing gain.

RESULTS: In terms of ARM and RMM measurements, there was no statistically significant difference between cases where postoperative infection control was assured and cases with ongoing infection; successful and failed cases in terms of grafting; or successful and failed cases in terms of postoperative hearing. When preoperative and postoperative air-bone gap averages were compared, statistically significant differences were observed.

CONCLUSION: In the presence of a nasal obstruction in cases with chronic otitis, elimination of this situation is the first line of treatment. Infection control, graft success, and improvement of hearing will be possible to a greater extent in the postoperative period for patients with the nasal pathology remedied.

KEYWORDS: Chronic otitis media, acoustic rhinometry, rhinomanometry

INTRODUCTION

Chronic otitis media (COM) is a disease characterized by continuous or recurrent perforation of the otorrhea, eardrum, and hearing loss following chronic inflammation of the middle ear cavity, ossicules, and mastoid cells [1]. Having a range incidence of 4–62% and prevalence of 2–52%, COM is a significant social problem in our country as in all societies [2]. In studies conducted in Turkey, COM prevalence is reported to be between 0.006 % and 2.6% [3].

Topical antibiotic drops and systemic antibiotics can be used for medical treatment in COM cases in the active period. Surgical treatment may be applied in cases not responding to medical treatment [1]. The main objective of COM surgery is to form a middle ear cavitation, which is well ventilated, provided with sound transmission, and remedied from inflammation. Many prognostic factors affecting hearing in cases with COM are discussed. Becvarovski and Kartush identified the key risk factors (discharge, cholesteatoma, tympanic membrane perforation, previous surgical history, granulation or effusion, smoking) for COM using the Middle Ear Risk Index [4]. As known, eustachian dysfunction plays an important role in COM etiopathogenesis and postoperative prognosis. It has been reported in literature that nasal obstruction plays a significant role in the formation of eustachian dysfunction [5]. In addition, it has been reported that eustachian dysfunction is frequently found in patients with turbinate and nasal septum deviation [6]. Pathologies of the nasal cavity are considered to adversely affect tympanoplasty and ossiculoplasty results, leading to eustachian dysfunction.

Acoustic rhinometry (ARM) and rhinomanometry (RMM) methods are most widely performed for the objective assessment of the nasal airway. RMM is a simultaneous measurement of nasal airflow and transnasal pressure. Pressure differences existing along the nose during nasal breathing create nasal airflow. Airflow can be measured by calculating the volume change either directly on nasal vestibule or indirectly on the thorax. A tube detecting the pressure in the active anterior RMM is fixed with a band in front of one of a nostril in such a manner so as to prevent air leakage. A mask covering the nose and mouth of the patient is placed on the face

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on the patient. Patient breathes through nose. As the patient will not be able to breathe through the nostril with the pressure tube, the pressure formed in the measurement tube is equal to the pressure on the other nostril [7].

Acoustic rhinometry is used to examine the nasal cavity geometry. The amount and location of the stenosis is calculated by using intensity, phase, and the delay time of reflecting acoustic signals sent to the nasal cavity [8]. The ARM device can calculate many parameters, such as dimension, location, the transverse cross-sectional areas of minimal cross-sectional area (MCA) in different distances from the nostrils and the total volume of nose by using a field-distance curve [7]. The horizontal segment prior to point "0" in the acoustic rhinogram represents the nasal adapter. Two notchings are observed following this. The first collapse is located in the isthmus nasi location and is named as notch "I". The second collapse belongs to the front end portion of the inferior turbinate and is named as notch "C". Notch "I" defines the geometric characteristics of the nasal valve area located in the first 2 cm in the narrowest part of the nasal cavity. There is no significant change in this part when applied topical decongestant. Notch "C" is the second narrowest area. It reflects the geometric characteristics of the top part of the inferior turbinate [9]. The ARM nasal provocation test is sensitive to changes in the nasal mucosa, such as effects of nasal cycle and to topical decongestants. It is proposed using the MCA value while assessing nasal affection by ARM [9].

In this study, ARM and RMM measures of the nasal cavity were made in cases operated due to COM, and the results were assessed in terms of postoperative eradication of the infection, graft success, and hearing gain. Through these, this study aimed to research the prognostic value of ARM and RMM in COM surgery.

MATERIALS and METHODS

Fifty-eight patients who underwent surgery with a diagnosis of COM between the years 2009 and 2014 in our clinics were prospectively included in this study. Patients were assessed in terms of age, gender, COM type, treatment methods applied, eradication of infection, graft success, and hearing gain. The COM type was detected by otoscopy and oto-microscopic examination. Cases were classified according to COM type as non-cholesteatomatous COM, cholesteatomatous COM, or adhesive COM. The types of surgery performed on patients were recorded. Patients undergoing open cavity mastoidectomy (radical mastoidectomy) and patients with nasal pathologies such as nasal septum forte deviation and nasal polyposis were excluded from study.

Patients underwent preoperative audiologic tests (Interacoustics AC40; Denmark), and the pure tone threshold averages were determined in this way. Patients had a rest during 15-20 minutes for the ARM and RMM measures, then appropriate probe leads, specifically and separately prepared for the right and left nostrils, were used. Measures were performed by the SRE2000 (Rhinometrics A/S; Lynge, Denmark) device, which produces an acoustic signal in the form of two truncated impulses. The cross-sectional areas, distance between them, and nasal cavity volume measurement results obtained from the measurement curves were detected by version 2.6 of the Rhinoscan software (Rhinometrics A/S; Lynge, Denmark). The absence of any signal leakage during the measurements was assured by both the measurement curves and acoustic signal noise changes occurring during the measurement. Patients in a sitting position were asked to silently breathe in through the mouth during the measurement recordings. Excluding the curves over the standard deviation of 2%, which was selected as an acceptable level, for the curves formed during the acoustic measurements made for each nostril, at least three calibration curves were obtained. The average value of the curve obtained from these three curves was recorded as the values for the relevant patient. The scales on the measurement curves detected automatically by the device were, respectively, as follows: the smallest cross-sectional area located within the first 2 cm from the nasal vestibule (MCA1), the smallest cross-sectional area located within the second or fifth cm from the nasal vestibule (MCA2), and the cross-sectional area located within the fifth cm fromthr nasal vestibule (MCA5). The cross-sectional area was in square centimeters (cm^2).

Prior to RMM, patients undergoing nasal cleansing with normal saline irrigation had a rest for 15–20 minutes in a room at a temperature of 20±3 degrees, humidity 50%, not intensively exposed to sunlight. It was important that they avoided taking exercise, drinking tea or coffee, and smoking 2 hours prior to the test. In the active anterior RMM measurements, the mask covered both the mouth and nose, and a pressure probe was passed through, inserted into a nostril, with a nasal flow probe inserted in the other nostril. While inserting the probes, attention was paid not to deform the nostrils and to assure the absence of any air leakage. Patients were asked to keep their mouths closed and to breathe in through the nose. The individual resistance of each nostril (Right and Left R) was calculated and then the total inspiratory nasal resistance (Total R) was calculated.

After surgery, postoperative controls were performed within 4–6 months. The postoperative examinations of patients were performed by otoscopy and automicroscopy, and the graft success and hearing status were assessed according to the eradication of infection and state of the tympanic membrane. Patients underwent a postoperative pure tone audiometry test in intervals ranging from 3 months to 4 years (average of 14 months), and by determining the preoperative and postoperative air-bone gap of each patient it was observed whether there was a statistically significant difference in the two or not. In addition, in line with the proposals of the American Academy of Otolaryngology-Head Neck Surgery (AAO-HNS), cases with a postoperative air-bone gap of 20 dB and below were considered successful in terms of hearing, while those with a postoperative air-bone gap above 20 dB were considered unsuccessful.

Acoustic rhinometry and RMM measurement values of cases with infection and without infection, successful (intact) and failed cases (perforated) in terms of tympanic membrane graft, and successful and failed postoperative cases in terms of hearing were statically compared.

The present study was conducted based on the principles of the Declaration of Helsinki and approved by the Ethics Committee of Çanakkale Onsekiz Mart University. Informed consent was obtained from all adult patients and from both parents of child patients.

Statistical Analysis

Statistical Package for the Social Sciences 19 (SPSS Corp.; Chicago, IL, USA) software was used for the statistical analysis. When evaluat-

ing study data, the Mann-Whitney U test was performed as well as descriptive statistical methods (average, standard deviation) during intergroup comparisons of the parameters with normal distribution in comparisons of the quantitative data. The Paired Sample test was performed for the intergroup comparison of parameters with normal distribution. Results were assessed in a confidence interval of 95 %, with significance assessed at the level of $p<0.05$.

RESULTS

A total of 58 patients (34 female and 24 male) were included in the study. The average age was 32.12±14.48 (13–62 years). Non-cholesteatomatous COM was observed in 46 patients (79.3%), adhesive COM in 7 cases (12.1%), and cholesteatomatous COM in 5 cases (8.6%). Thirty-one cases (53.4%) underwent tympanomastoidectomy, 25 cases (43.1%) underwent tympanoplasty type 1, and 2 cases (3.5%) underwent open cavity modified mastoidectomy technique (modified radical mastoidectomy). Oil, tragal cartilage, temporal muscle fascia, fascia, and tragal cartilage graft were used simultaneously.

While infection was controlled in 56 cases (96.6%) in the postoperative period, 2 cases (3.4%) had signs of infection in the postoperative period. The postoperative graft success rate was 87.9%. While hearing gain was achieved in 38 cases (65.5%) in the postoperative period, there was no achievement in terms of hearing in 20 patients (34.5%).

The average preoperative air-bone gap was 30.00±11.54 dB, and the average postoperative air-bone gap was 20.71±11.09 dB, and it was detected that there was a statistically significant difference between the averages of the preoperative and postoperative air-bone gaps ($p<0.05$) (Table 1).

When the ARM and RMM measurements of cases with and without infection control in the postoperative period were compared, it was detected that there was no statistically significant difference between them ($p>0.05$) (Table 2).

In our study, no statistically significant difference was observed between ARM and RMM of the group with an intact graft and those with a perforated graft in the postoperative period ($p>0.05$) (Table 3).

In successful cases, while the right nasal cavity resistance was 1.62±1.56, the left nasal cavity resistance was 2.96±5.95 and the total resistance was 0.67±0.33 in RMM in terms of postoperative hearing; in failed cases, the right resistance was 2.01±1.88, left resistance was 2.38±2.47, and total resistance was 0.91±0.58. No statistically significant difference was observed between ARM and RMM of the group with a hearing gain in the postoperative period and the group with failed cases ($p>0.05$) (Table 4).

DISCUSSION

Despite various studies being conducted about the prognostic factors that play a role in achieving successful or failed results in chronic otitis surgery, there is no accepted standardization for all over the world. SPITE (surgery, prosthesis, infection, tissues, and eustachian tube), OOPSI (ossiculoplasty, outcome, parameter staging index), and middle ear risk index are some of the proposed methods [4, 10, 11].

Table 1. The distribution of cases by preoperative and postoperative air-bone gap

Air-bone gap	Preoperative number of patients (%)	Postoperative number of patients (%)
0-10 dB	0 (0)	9 (15.5)
11-20 dB	17 (29.3)	29 (50)
21-30 dB	14 (24.1)	11 (19)
31-40 dB	16 (27.6)	5 (8.6)
41-50 dB	9 (15.5)	3 (5.2)
>50 dB	2 (3.4)	1 (1.7)
Total	58 (100)	58 (100)

dB: decibel

Table 2. A comparison of rhinomanometry and acoustic rhinometry measurements in patients whose postoperative infections were controlled and those whose postoperative infections were not controlled

	Infection absent	Infection present	p
Right R	1.82±1.72	0.99±0.66	0.512
Left R	2.86±5.13	1.78±0.03	0.412
Total R	0.78±0.46	0.60±0.28	0.652
Right MCA1	0.77±0.18	0.61±0.11	0.187
Right MCA2	0.57±0.31	0.48±0.26	0.748
Right MCA5	2.40±1.28	1.98±0.74	0.748
Left MCA1	0.78±0.18	0.62±0.37	0.519
Left MCA2	0.63±0.28	0.65±0.18	0.657
Left MCA5	2.39±1.32	2.32±0.40	0.748

R: resistance; MCA: minimal cross-sectional area
Statistically significant differences; significance level $p<0.05$

Table 3. A comparison of rhinomanometry and acoustic rhinometry measurements in patients with a postoperative intact graft or perforated graft

	Intact graft	Perforated graft	p
Right R	1.87±1.79	1.21±0.57	0.647
Left R	2.92±5.36	2.14±1.69	0.872
Total R	0.77±0.46	0.70±0.38	0.795
Right MCA1	0.76±0.18	0.79±0.20	0.716
Right MCA2	0.58±0.32	0.48±0.18	0.734
Right MCA5	2.39±1.34	2.38±0.61	0.544
Left MCA1	0.76±0.16	0.87±0.29	0.126
Left MCA2	0.65±0.29	0.48±0.08	0.140
Left MCA5	2.45±1.35	1.97±0.76	0.380

R: resistance; MCA: minimal cross-sectional area
Statistically significant differences; significance level $p<0.05$

As well as playing a role in COM etiopathogenesis, eustachian dysfunction is one of the most important reasons for postoperative failure. In the literature, it has been reported that development of the eustachian is linked to an effect of relevant nasal obstruction to the development of a nasomaxillary complex and skull base and that nasal obstruction plays an important role in eustachian dysfunction [5,12]. In addition, it has been emphasized that eustachian dysfunction

Table 4. A comparison of rhinomanometry and acoustic rhinometry measurements of groups with a hearing gain in the postoperative period and the group with failed cases

	Postoperative hearing gain	Postoperative hearing failed	p
Right R	1.62±1.56	2.01±1.88	0.167
Left R	2.96±5.95	2.38±2.47	0.314
Total R	0.67±0.33	0.91±0.58	0.195
Right MCA1	0.76±0.18	0.76±0.20	0.722
Right MCA2	0.59±0.32	0.51±0.27	0.387
Right MCA5	2.54±1.32	2.01±1.02	0.121
Left MCA1	0.78±0.17	0.74±0.20	0.545
Left MCA2	0.62±0.26	0.61±0.28	0.574
Left MCA5	2.34±1.16	2.40±1.46	0.993

R: resistance; MCA: minimal cross-sectional area
Statistically significant differences; significance level p<0.05

is found frequently in patients with turbinate and nasal septum deviation [6]. Low and Willatt [13] reported that middle ear pressure on the deviated side after septoplasty decreased significantly. Watson [14] detected that nasal obstruction on unilateral COM is important and that nasal airway resistance is higher at the side of the ear affected. Pathologies of the nasal cavity adversely affect tympanoplasty and ossiculoplasty results, leading to eustachian dysfunction. In our study, the anatomy and physiology of the nasal cavity were objectively assessed, and the prognosis effects on patients operated due to COM were researched. For this purpose, the results obtained from both postoperative otoscopic and microscopic examination, and the preoperative and postoperative hearing test results were compared with measurements of ARM and RMM. In this way, the prognostic value of the parameters, such as total nasal resistance, were assessed.

The cross-sectional area of the nasal cavity in tympanoplasty surgery was also discussed herein. ARM and RMM methods are most widely performed for the objective assessment of the nasal airway. RMM is a simultaneous measurement of nasal airflow and transnasal pressure [7]. Normally, inspiratory nasal airway resistance in non-decongestant noses ranges from 0.34–0.40 Pa/cm^3/s (average, 0.39); and 0.25–0.30 Pa/cm^3/s (average, 0.26) after decongestion per person. Even though each nasal cavity resistance changes during the day, total nasal resistance remains constant [7]. ARM was used to examine the nasal cavity geometry. The amount and location of the stenosis was calculated by using the intensity, phase, and delay time of reflecting acoustic signals sent to the nasal cavity [8]. Grymer et al. [15] observed MCA as 0.72–0.73 cm^2 prior to topical decongestant application in asymptomatic persons; and as 0.92–0.95 cm^2 after decongestatiton [15].

Güçlü et al. [16] reported that the relationship between COM and nasal parameters was observed to be statically high at a significant level compared to nasal resistance in cases with COM. However, there was no statistically significant difference detected between the ARM values of these two groups. The fact that nasal resistance is different between two groups in RMM was linked to mucosal changes. However, in our study, when we considered the nasal cavity effect on prognosis in patients operated on due to COM, there was no statistically significant difference observed between the ARM and RMM measurements of cases with and without infection control. However, when successful and failed grafts and successful and failed cases in terms of hearing were compared in terms of ARM and RMM, there was no statically significant difference.

One object of tympanoplasty operations is to form a closed self-ventilated cavity. Demirpehlivan et al. [17] reported the graft attachment success in the tympanoplasty surgery of type 1 as 97.7% in the group using palisade cartilage; 79% in the group using an island graft of perichondrium cartilage; and 80.6 % in fascia group; with the average of the three groups reported as 85% . Coelho et al. [18] detected the success rate in patients having cartilage tympanoplasty surgery as follows: 92.9% in a smoking group; 90.6 % in a non-smoking group. Hod et al. [19] detected the graft success rate in the inlay butterfly cartilage tympanoplasty technique as 92.5% [19]. In our study, there was a group of solely fascia, solely cartilage, and a heterogeneous group with fascia and cartilage used simultaneously. In our study, the graft attachment success rate was 87.9%, regardless of the graft material used. In our study, there was no significant difference between the ARM and RMM measurements of groups with intact graft or a perforated graft in the postoperative period.

One of the aims of COM surgery is hearing gain. Considering air-bone gap gains obtained in different studies, success rates range from 92.5 to 55% [20]. In our study, the hearing gain of the air-bone gap of was achieved with a 65.5% success rate, with a hearing gain of 9.29 dB. In the literature, the air-bone gap gains in different studies range between 8.2–27 dB [20]. There was no significant difference between the ARM and RMM measurements of successful and failed cases in terms of postoperative hearing. However, when comparing the preoperative and postoperative air-bone gap averages, a statistically significant difference was observed (p<0.05). Considering these findings, it is understood that better results can be obtained in postoperative hearing in patients with a more advanced eustachian function and nasal anatomy and physiology, according to the objective nasal measurement results.

In conclusion, according to data obtained when comparing ARM and RMM measurements of cases where postoperative infection control was assured and cases with ongoing infection, no statistically significant difference was observed. Similarly, no significant difference was observed between the ARM and RMM measurements in successful and failed graft cases. This finding is in fact an expected condition because if the patients undergoing ear surgery have upper respiratory tract pathologies, the treatment should be applied accordingly. In addition, the elimination of this situation in the presence of nasal obstruction in patients with chronic otitis is the first line of treatment. We believe that the attention paid to the selection of patients led to this result. However, when comparing successful and failed cases in postoperative hearing, no significant difference was observed between the ARM and RMM measurements in successful and failed graft cases. Nevertheless, when comparing preoperative and postoperative air-bone gap averages, a statically significant difference was obtained. Considering this finding, it is understood that better results can be obtained in the postoperative hearing in patients with a more advanced eustachian function and nasal anatomy and physiology, according to the objective nasal measurement results.

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

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