

The Effects of Smoking on Eustachian Tube Function and Surgical Outcomes in Patients with Chronic Otitis Media

Sigaranın Kronik Otitis Media Hastalarında Östaki Tüpü Fonksiyonu ve Cerrahi Sonuçlar Üzerindeki Etkileri

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ABSTRACT Objective: Effect of smoking on the Eustachian tube (ET) function is unknown specifically in humans. The literature about smoking as a prognostic factor in chronic otitis media (COM) surgery is showing discrepancies. We evaluated the ET function by the saccharin test. Test results compared between smokers and nonsmokers. Surgical outcomes were assessed between groups according to smoking status and ET function. **Material and Methods:** A prospective case series was conducted at a tertiary referral center on 83 COM patients undergoing endoscopic Type 1 cartilage tympanoplasty. Patients were classified based on saccharin test results into 3 groups; normal function, partial dysfunction, and gross dysfunction. Smoking status was used to evaluate ET function, and perforations were categorized as anterior, central, or posterior. Surgical success rates were compared between smokers and non-smokers. **Results:** The saccharin test showed no significant difference in ET function between smokers and non-smokers. Patients with gross dysfunction had more anteriorly localized perforations. Surgical success rates did not significantly differ between smokers and non-smokers, and ET function did not affect outcomes. **Conclusion:** Anteriorly localized perforations in tympanic membrane should bring to mind the ET dysfunction. Tragal cartilage is a reliable graft material for patients with smoking history and ET dysfunction.

ÖZET Amaç: Sigaranın östaki borusu üzerindeki etkisi (ET) işlevi özellikle insanlarda bilinmemektedir. Kronik otitis media (KOM) cerrahisinde prognostik bir faktör olarak sigara kullanımı hakkındaki literatür tutarsızlıklar göstermektedir. ET fonksiyonunu sakarin testi ile değerlendirdik. Test sonuçları sigara içenler ve içmeyenler arasında karşılaştırıldı. Gruplar arasındaki cerrahi sonuçlar sigara içme durumu ve ET fonksiyonuna göre karşılaştırıldı. **Gereç ve Yöntemler:** Üçüncü basamak bir merkezde, endoskopik Tip 1 kıkırdak timpanoplasti uygulanan 83 kronik otit hastası üzerinde prospektif bir olgu serisi çalışması yapıldı. Hastalar sakarin testi sonuçlarına göre 3 gruba ayrıldı; normal işlev, kısmi işlev bozukluğu ve ileri işlev bozukluğu. Östaki tüpü fonksiyonunu değerlendirmek için sigara içme durumu kullanıldı ve perforasyonlar anterior, santral veya posterior olarak kategorize edildi. Sigara içenler ve içmeyenler arasında cerrahi başarı oranları karşılaştırıldı. **Bulgular:** Sakarin testi, sigara içenler ve içmeyenler arasında östaki tüpü fonksiyonunda anlamlı bir fark göstermedi. İleri derecede disfonksiyonu olan hastalarda perforasyonlar daha anterior yerleşimliydi. Cerrahi başarı oranları, sigara içenler ve içmeyenler arasında anlamlı bir farklılık göstermedi ve östaki tüpü fonksiyonu sonuçlarını etkilemedi. **Sonuç:** Timpanik membranda anterior yerleşimli perforasyonlar östaki borusu disfonksiyonunu akla getirmelidir. Tragal kartilaj, sigara öyküsü ve östaki tüpü disfonksiyonu olan hastalar için güvenilir bir greft materyalidir.

Keywords: Smoking; Eustachian tube function; chronic otitis media; endoscopic tympanoplasty; tragal cartilage

Anahtar Kelimeler: Sigara içmek; Östaki tüpü fonksiyonu; kronik otitis media; endoskopik timpanoplasti; tragal kartilaj

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The Eustachian tube (ET) is a dynamic tunnel which has the following functions: pressure equalization and protection and clearance of the middle ear cavity.¹ The ET opens during swallowing, yawning, and sneezing by the contraction of the tensor veli palatini. This active opening allows ventilation and gas exchange in the middle ear cavity. The histology of ET has a vital role on its function. The bony part is lined by a cuboidal ciliated mucosa of the middle ear. The mucosa transits to pseudostratified ciliated columnar epithelium in the cartilaginous part. The cilia transport mucous from the tympanic opening of the tube towards the nasopharynx as a part of the mucociliary function. It is well known that ET dysfunction may end with various middle ear pathologies such as otitis media with effusion, adhesive otitis media, and chronic otitis media (COM).²⁻⁵ But there is little data available on ET function and the surgical outcome of the otitis media.

The prognostic factors for COM have been extensively studied. Outcomes are also dependent on the extent of surgery and the type of the material used for grafting. However, ET dysfunction and its role in surgery outcomes remain mostly unspecified. Ventilator function of the ET does not seem to affect the surgical results, but impairment of mucociliary function may have an effect on hearing results after surgery.⁶ It has been shown that smoking affects the ET by affecting mucociliary clearance in the short term and causing squamous metaplasia in the long term, in an animal model.⁷ The reports about the role of smoking on the pathogenesis of COM and its effect on surgery outcomes show discrepancies.^{8,9} But there is no existing data on whether smoking affects ET function in COM. It has been shown that the saccharin test gives valuable information about both the patency and mucociliary function of the ET.^{6,10}

In this study, we aimed to show the effect of smoking on ET function in patients with COM. We also aimed to clarify the prognostic role of ET dysfunction and smoking in patients undergoing cartilage tympanoplasty.

MATERIAL AND METHODS

This study has been performed in the otolaryngology department of a tertiary referral center and approved

by the Ümraniye Training and Research Hospital Clinical Researches Ethics Committee (date: April 13, 2017; no: 34). The study was conducted in accordance with the Declaration of Helsinki. Eighty three participants were involved in the study. All patients underwent under-overlay cartilage tympanoplasty. Patients needing mastoidectomy or patients having an air bone gap of more than 35 dB in pure tone audiometric evaluation, or a history of previous ear surgery were excluded from the study to obtain homogeneity of the groups.

PREOPERATIVE ASSESSMENT

All the participants had full otolaryngologic examination, and their smoking history was also noted. Smoking history was defined as pack-year and calculated as multiplying the number of packs of cigarettes smoked per day by the number of years the patients have smoked. Perforations were classified according to localization and relation of perforations with the external auditory canal: as anterior, central, or posterior, as marginal or central. Pure tone audiometry (PTA) and a saccharin test were performed to evaluate hearing status and ET function, respectively.

SACCHARIN TEST

A saccharin tablet (Takita, Egepak Gıda Pazarlama Sanayi, İzmir, Türkiye) was used for each patient. The patient sat on the chair and one Takita saccharin tablet was placed in the middle ear cleft through perforation under endoscopic view. The time interval between placement of the tablet and the patient's sensation of sweetness [saccharin perception time (SPT)] was measured in minutes. Prasad defined that an SPT of less than 20 minutes was normal, between 20 and 45 minutes was classified as a partial dysfunction and more than 45 minutes was classified as gross dysfunction.¹⁰ Participants who did not sense saccharin after 45 minutes were re-evaluated by directly placing the saccharin on the tongue. Informed consent was obtained from all individual participants included in the study.

SURGERY

All the patients underwent endoscopic cartilage tympanoplasty under general anesthesia. The donor site

was ipsilateral tragal cartilage in all patients. After local anesthesia by injection to minimise intraoperative bleeding, margins of perforations were deepithelialised. Tympanomeatal flap elevation was followed by grafting, through underlying the rest of the tympanic membrane and overlaying the manibrium malleus. The graft was supported medially by a gelatin sponge in the middle ear cavity.

POSTOPERATIVE ASSESSMENT

All the patients had a microscopic examination in the first week, at the 1st month, and in the 6th month after the operation. Hearing evaluations were done at the 6th month and the 12th month postoperatively with PTA. Anatomical success was defined as the absence of re-perforation, retraction or medialisation of the graft material. Functional success criterion was the reduction of the air bone gap to less than 20 dB.

STATISTICAL ANALYSIS

Descriptive statistics were utilized to assess the data, including measures such as mean, standard deviation, median, minimum, maximum, frequency, and ratio values. The distribution of variables was examined using the Kolmogorov-Smirnov test. For the analysis of independent quantitative data, both the independent sample t-test and Mann-Whitney U test were employed. In the case of independent qualitative data, the chi-square test was utilized, and when the conditions for the chi-square test were not met, the Fischer test was used as an alternative. The data analysis was conducted using the SPSS 28.0 software (IBMM,USA).

RESULTS

Eighty-three (40 female, 43 male) patients were involved in the study. Patients’ ages varied between 18 and 58 years (mean 34.4 years). According to saccharin test results, 26 patients had normal ET function, 34 patients had partial loss of ET function, and 23 patients had gross ET dysfunction. Demographic characteristics are summarized in Table 1. Thirty-eight of 83 patients had at least 10 packs-year smoking history.

Localization of perforation was anterior in 30 patients, central in 23 patients, and posterior in 30 patients. Nineteen out of 26 patients (73%) with gross

TABLE 1: Demographical and clinical characteristics of patients.

n	83 (40 female, 43 male)
Age	18-58 years (Mean 34.4 years)
ET function	
Normal	26
Partial dysfunction	34
Gross dysfunction	23
Smoking status	
Smokers	38
Nonsmokers	45
Perforation localization	
Anterior	30
Central	23
Posterior	30
Anatomical success rate	66/88(80.7%)
Functional success rate	68/83(81.9%)

ET: Eustachian tube.

ET dysfunction had an anteriorly located perforation. Anteriorly located perforations were encountered significantly more in the gross ET dysfunction group than in the other groups (p=0.005) (Table 2). Centrally or posteriorly located perforations did not show a difference among ET function groups.

The mean PTA for air conduction was 32.5±3.8 dB preoperatively and 24.4±2.8 dB at the 6th month and 20.2±2.1 dB at the 12th month for all patients.

There was no statistically significant difference in smoking status among the groups that had the ET function evaluated (p=0.384).

The anatomical success rate was 21/26 (81%) in patients with a normal ET function, 27/34 (80%) in

TABLE 2: Patients’ characteristics according to ET function. Comparison of perforation localization differed between groups. Patients with gross dysfunction of ET had significantly more anteriorly localized perforations than partial dysfunction and normal ET function group.

	Eustachian Tube Function		
	Normal 26	Partial Dysfunction 34	Gross Dysfunction 23
Number of cases			
Age (Mean, years)	33.1	37.9	29.5
Perforation localization			
Anterior	6	8	16
Central	8	10	5
Posterior	12	16	2

*p=0.007, **p=0.004 respectively; ET: Eustachian tube.

patients with partial ET dysfunction, and 18/23 (79%) in patients with gross ET dysfunction. There was no statistically significant difference between groups when the anatomical success rate was evaluated ($p=0.397$). In the postoperative 12th month, air bone gap (ABG) improvement was 10.8 ± 0.7 dB in patients with normal ET function, 10.9 ± 0.9 dB in patients with partial ET dysfunction, and 11.8 ± 1.1 dB in patients with gross ET dysfunction. Variances between groups was not statistically significant.

The anatomical success rate was 31/38 (81.5%) in smokers and 36/45 (80%) in nonsmokers. At the postoperative 12th month, ABG improvement was 10.5 ± 1.2 dB in smokers and 10.8 ± 0.9 dB in nonsmokers. There was no significant difference in anatomical success rate and the functional success rate between smokers and nonsmokers (Table 3) ($p=0.682$, $p=0.125$ respectively).

DISCUSSION

Evaluation of prognostic factors for surgical outcomes of COM always attracts attention. Success in COM surgery is mostly assessed by anatomical success and functional success. Anatomical success is considered to be the presence of an intact graft without any medialization or adhesion of graft material. Functional improvement includes a decrease in the air bone gap in audiologic evaluation. There are numerous studies measuring prognostic factors for tympanoplasty.

In our study, we aimed to evaluate the relationship between smoking and ET dysfunction in outcomes of COM surgery. It is hypothesized that smoking mainly has three effects in the middle ear and ET. Firstly, the direct local effect of smoke on

ET mucosa. Secondly, smoking causes inflammation and edema in middle ear cavity. This may block the ET anatomically. Lee et al. showed that direct exposure to smoke caused loss of cilia, goblet cells, and squamous metaplasia in the short term in rats. In the long term, cilia and goblet cell decrement recovered.⁷ This finding should suggest that the mucociliary activity of ET may not be affected in long-term smokers due to chronic exposure. This was consistent with our study. We did not find any difference for ET function between smokers and nonsmokers. We suggest that smoking does not affect mucociliary function of ET in COM. Since saccharin test also shows patency of ET, we were also able to show that smoking did not cause occlusion of the ET in COM.⁵ A third effect of smoking on ET was hypothesized as having a systemic effect of generating mediators, and metabolites. This would cause end organ disease of smoking such as in other parts of the body. However, there is no data showing specific systemic effect of smoking on the ET. This may be one of the weaknesses of our study, that we did not examine systemic effects of smoking on ET function.

Salviz et al. studied preoperative factors influencing the success rate in Type 1 tympanoplasty. They evaluated age, history of ear surgery, the situation of contralateral ear, perforation size, adenoid hypertrophy, and smoking as preoperative factors. However, none of the mentioned factors was associated with success rates in tympanoplasty where cartilage has been used as graft material.⁸ Uguz et al. measured serum cotinine levels for tympanoplasty success.¹¹ Cotinine is a major product of nicotine metabolism. Its measurement can give objective information about the smoking status of patients. They found that smoking was negatively affecting the suc-

TABLE 3: Patients characteristics and surgical outcomes due to smoking status. There was no difference between smokers and nonsmokers in patients going cartilage tympanoplasty for chronic otitis media according to age, perforation localization, anatomical and functional SR.

	n	Age (mean, years)	Perforation Localization			Anatomical SR	ABG improvement (dB)
			Arterior	Central	Posterior		
Smoke	38	35.7	17	12	14	30/38(78%)	10.5±1.2
Nonsmokers	45	33.1	13	11	16	36/45(80%)	10.8±0.9
p value		0.434		0.527		0.682	0.612

SR: Success rate. ABG; Air Bone Gap

cess rates, in a study involving 77 patients. Only 19 of them (24%) were smokers. Of the patients, 56 had a serum cotinine level below 17.7 ng/mL and 21 patients above that. The authors did not explain the discrepancy between the number of smokers (19/77) and number of patients having serum cotinine level above the cut point (21/77). The article did not mention the perforation size and location of perforations which can affect success rates. Twenty six percent of patients had atticotomy, 35% of them had intact canal wall mastoidectomy, and 6% of them had canal wall down mastoidectomy, and 17% patients had ossicular chain reconstruction. Only 31% of patients had just Type 1 tympanoplasty. This heterogeneity of surgical procedures may easily misdirect analysis of the results. We performed our study in patients having only Type 1 tympanoplasty in order to prevent this problem. However, Becvarovski and Kartush stated that cigarette smoking has a three-fold increase risk for graft failure in the long term.⁹ They offered a new scoring system called the middle ear risk index for evaluating preoperative and intraoperative risk factors for tympanoplasty prognosis. They revised this scoring system with insertion of smoking as a risk factor. However, the study was performed in 74 patients of whom only 15 were cigarette smokers. Additionally, they used temporalis muscle fascia as the graft material in all patients. We disagree about the proposal of smoking as a risk factor based on the success rates of muscle fascia grafts. Studies demonstrated that cartilage tympanoplasty should be recommended for any patients who smoke and are having tympanoplasty.^{12,13} Thus, we have performed cartilage tympanoplasty in all cases in order to prevent potential bias affected by graft material choice. In our study, there was no significant difference between smokers and nonsmokers in both anatomical and functional success in patients who had Type 1 cartilage tympanoplasty. We suggested that cartilage is a reliable graft material in patients with a history of smoking having Type 1 tympanoplasty.

We also wanted to study the effect of ET dysfunction in Type 1 tympanoplasty outcomes. Ikehata et al. showed that the saccharin test can be used to assess ET function in COM (we used the same protocol to assess ET dysfunction), so they divided patients into a

normal ET function group, a partial dysfunction group and a gross dysfunction group. They stated that the gross ET dysfunction group had a lower hearing improvement.⁶ There was no significant difference between the partial ET dysfunction group and the normal group. Anatomical graft success was similar between groups. In our study, hearing improvement was higher in the normal ET function group than both in the partial and gross dysfunction groups. However, this difference was not statistically significant. Anatomical success was no different between groups. We were able to improve hearing outcomes in the partial and gross dysfunction group. We suggest that this was due to our graft material choice. We used tragal cartilage in all cases. Ikehata et al. had used temporal fascia as the graft material.⁶ So, we concluded that in patients having Type 1 tympanoplasty due to COM with ET dysfunction, cartilage may be superior to temporalis fascia as a graft material in order to obtain hearing improvement. However, ET dysfunction did not affect anatomical success rates. Anterior localized perforations were more commonly seen in patients in the gross ET dysfunction group. We conclude that anterior localized perforations should bring to mind ET dysfunction.

CONCLUSION

To the best of our knowledge, this is the first study evaluating the relationship between smoking and ET function in COM. We concluded that smoking does not influence ET functions in COM. Anterior localized perforations were mostly related with gross ET dysfunction. Cartilage is an appropriate graft material for patients having tympanoplasty with a history of smoking or ET dysfunction, for both anatomical and functional success.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise,

working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: Burak Karabulut, Serap Önder; **Design:** Şamil Şahin, Burak Karabulut; **Control/Supervision:** Burak Karabulut, Serap Önder; **Data Collection and/or Processing:** Betül

Aktaş, Yaşar Kemal Duymaz, Ahmet Mahmut Tekin; **Analysis and/or Interpretation:** Şamil Şahin, Burak Erkmən; **Literature Review:** Yaşar Kemal Duymaz, Ahmet Mahmut Tekin; **Writing the Article:** Şamil Şahin; **Critical Review:** Burak Karabulut, Serap Önder; **References and Fundings:** Ahmet Mahmut Tekin, Betül Aktaş; **Materials:** Yaşar Kemal Duymaz, Burak Erkmən.

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