ORIGINAL ARTICLE

The effectiveness of repairment of traumatic tympanic membrane perforations with cigarette paper

Özlem Akkoca, M.D., Selda Kargın Kaytez, M.D., Zeynep Kaptan, M.D., Coşkun Özdemir, M.D.

Department of Otorhinolaryngology, University of Health Sciences, Ankara Training and Research Hospital, Ankara-*Turkey*

ABSTRACT

BACKGROUND: The aim of this study was to evaluate the effects of repairment of traumatic tympanic membrane perforation (TTMP) with cigarette paper patch (CPP) on perforation closure and hearing functions.

METHODS: A retrospective evaluation was made of 67 ears of 61 patients diagnosed with TTMP and treated with CPP in our clinic between January 2015 and 2019. In the classification of TTMP size, the entire tympanic membrane was evaluated as 100%, perforation of <25% was considered small, perforation of between 25% and 50% was considered medium and perforation of ≥50% was considered large. Audiological examination was performed before and at 3 months after the CPP procedure. Air conduction (AC) and bone conduction (BC) pure tone averages (PTAs) and air-bone gap (ABG) at 0.5, 1, 2, and 4 khz frequencies were compared.

RESULTS: Perforations were small in 20 (29.9%) of 67 ears, medium in 27 (40.2%), and large in 20 ears (29.9%). AC PTA before CPP was found to be 28.26±5.63 dB hearing level (HL), BC PTA was 8.80±4.35 dB HL and ABG was 19.26±5.80 dB HL. After CPP, the AC PTA was found to be 11.90±6.59 dB HL, BC PTA was 8.29±4.05 dB HL, and ABG was 14.10±4.66 dB HL. TTMP was determined to have improved in 61 ears (91%) in the 1st month after CPP application. There was no statistically significant difference between perforation size and improvement rates ($p>0.05$). AC PTA values after CPP application were determined to be significantly lower than AC PTA values before CPP application at 0.5, 1, 2, and 4 khz ($p<0.001$). The ABG values measured at 0.5 khz after CPP were significantly higher than the values measured at 2 khz. and 4 khz. ($p<0.001$, $p<0.001$, respectively). The amount of decrease in PTA value after CPP was found to be significantly greater at 0.5 khz than at 2 khz and 4 khz ($p<0.001$, $p<0.001$, respectively).

CONCLUSION: In the treatment of TTMP, early application of CPP is an effective treatment method in terms of both perforation closure and hearing gain.

Keywords: Hearing loss; trauma; tympanic membrane; tympanic membrane perforation.

INTRODUCTION

Traumatic tympanic membrane perforation (TTMP) is a common problem in otorhinolaryngology clinics. These perforations can develop due to different causes such as penetrating trauma, barotrauma, and head trauma. The tympanic membrane (TM) makes an important contribution to the sound transmission to the osicular system. Therefore, in cases of TTMP, conductive hearing loss is generally observed.[1,2]

TTMP often closes spontaneously and in some cases leads to middle ear infection and/or does not heal and can lead to conductive hearing loss. Surgical interventions, such as tympanoplasty or myringoplasty may be required in cases that do not heal or have inadequate recovery.[3] These surgeries are more costly than non-surgical methods and morbidity is higher. Therefore, non-surgical procedures that can be performed in office conditions using substances that facilitate TM regeneration are important.[4–6]

Paper patches have been in common use for a long time, and previous studies have shown that the use of paper patches can eliminate the need for surgical intervention. Therefore, repairing the perforation with a paper patch not only pre-

Cite this article as: Akkoca Ö, Kargın Kaytez S, Kaptan Z, Özdemir C. The effectiveness of repairment of traumatic tympanic membrane perforations with cigarette paper. Ulus Travma Acil Cerrahi Derg 2022;28:217-221.

Address for correspondence: Özlem Akkoca, M.D.
Sağlık Bilimleri Üniversitesi, Ankara Eğitim ve Araştırma Hastanesi, Kulak Burun Boğaz Hastalıkları Kliniği, Ankara, Turkey
Tel: +90 312 - 595 30 00 E-mail: o.ozturkakkoca@gmail.com

Ulus Travma Acil Cerrahi Derg 2022;28(2):217-221 DOI: 10.14744/tjtes.2020.98968 Submitted: 25.07.2020 Accepted: 06.11.2020

vents complications but also provides an advantage in terms of cost and time.[7] The aim of this study was to evaluate the results of TTMP repaired with cigarette paper. This is one of the very few studies in literature to have evaluated the effect of cigarette paper application on both perforation closure and hearing functions in TTMP.

MATERIALS AND METHODS

Evaluation of Cases

Approval for this retrospective study was granted by the Clinical Ethics Committee of the Health Sciences University Training and Research Hospital. The study included 67 ears of 61 patients, aged ≥18 years, who presented at our clinic between January 2015 and 2019, were diagnosed as in the first 7 days of TTMP and were treated with cigarette paper patch (CPP) after the exclusion of middle ear infection, severe vertigo, deep hearing loss, and facial paralysis. Following routine ear nose throat system examination, the size of the perforation was determined by otoscope after cleaning blood clots from the external ear canal with a cotton applicator dipped in povidone-iodine solution. As in previous studies, the size of TTMP was evaluated by accepting the whole TM as 100%.[8]

Perforations <25% were classified as small, between 25% and 50% as medium, and ≥50% as large. Patients were examined 1 month after the procedure to evaluate the improvement in perforation. Audiological examinations were performed before and at 3 months after the CPP procedure (Interacoustics AS DK-5610, Denmark). Air conduction pure tone average (AC PTA), bone conduction pure tone average (BC PTA), and air bone gap (ABG) average values at 0.5, 1, 2, and 4 khz frequencies were compared.

Preparation of the Study Materials

The paper patches were prepared from cigarette papers and sterilized with ethylene oxide gas. Cigarette papers were cut into 1×1 cm^2 pieces and placed in sterile tubes. Then, 5 cc Dulbecco's modified Eagle's (DMEM) without phenol red was added to the tubes, and the saturated products were collected after incubation at 37°C for 24 h at 24°C.

Surgical Procedure

Before the surgical procedure, informed consent was obtained from all patients, explaining the possible results and alternative surgical treatment options regarding the procedure to be performed. All applications were carried out by the same surgeon. Before the procedure was performed, all TMs were examined and it was ensured that there was no infection in the perforations and they were all dry. For local anesthesia, 10% lidocaine (Veracaine spray; SungKwangPharm, Cheonan, South Korea) was applied. The edges of the perforations were freshened using a sickle knife under the otomicroscope. The previously prepared and sterilized CPP was then placed on the perforation and shaped according to the size of the perforation.

Statistical Analysis

Data obtained in the study were analyzed statistically using IBM SPSS Statistics vn. 20 software. In the descriptive statistics, continuous variables were reported using mean±standard deviation, median, minimum and maximum values, and categorical variables were stated asa number (n) and percentage (%). Conformity of the data to normal distribution was assessed with the ShapiroWilk test.

In the comparisons of measurements at different frequencies before and after CPP application, the Wilcoxon test was used. The Friedman test was applied to evaluate the differences between frequencies pre-operatively and post-operatively. The frequency values of the difference (post hoc test) were examined with the Friedman multiple comparison test. The Chi-square and Fisher's Exact tests were used in group comparisons (cross tables) of nominal variables, and the relationship between perforation size and hearing values was examined with Spearman's Correlation Coefficient. A value of $p<0.05$ was accepted as statistically significant.

RESULTS

Evaluation was made of the data of 67 ears of 61 patients, comprising 34 (55.7%) females and 27 (44.3%) males, with a mean age of 27.33±9.13 years (range, 16–55 years). The perforation was classified as small in 20 (29.9%) of 67 ears, medium in 27 (40.2%), and large in 20 (29.9%). Perforation closure in the 1st month after CPP was detected in 61 ears (91%). Closure was observed in all ears with small perforations, in 25 (92.6%) ears with medium-sized perforation and in 16 (80%) ears with large perforations. There was no statistically significant difference between closure rates according to perforation size ($p>0.05$) (Table 1).

AC PTA value before CPP application was found to be 28.26±5.63 dB hearing level (HL), BC was 8.80±4.35 dB HL, and ABG was 19.26±5.80 dB HL. After CPP application, AC PTA was determined as 11.90±6.59 dB HL, BC PTA was 8.29±4.05 dB HL, and ABG was 14.10±4.66 dB HL. At 0.5, 1, 2, and 4 khz, the AC PTA values after CPP were significantly

Table 1. Comparison of perforation size and perforation closing rates

	Closed perforation		Unclosed perforation		p-value
	n	%	n	%	
Perforation size					
<25%	20	100	–	–	0.116
Between 25%–50%	25	92.6	2	7.4	
≥50%	16	80	4	20	

*Fisher's Exact Test.

Table 2. Comparison of AC PTA values before and after CPP application

AC PTA (dB HL)	Before CPP		After CPP		p-value*
	Mean±SD	Median (Min-Max)	Mean±SD	Median (Min-Max)	
0.5 khz	31.34±6.43	30 (20–45)	11.72±7.15	10 (0–40)	0.001
1 khz	29.03±6.23	30 (15–50)	11.42±7.22	10 (0–40)	0.001
2 khz	26.19±4.36	25 (20–35)	11.87±6.33	10 (5–35)	0.001
4 khz	26.49±5.51	25 (15–35)	12.61±5.66	10 (0–30)	0.001
p**	0.000		0.205		

AC PTA: Air conduction pure tone average; CPP: Cigarette paper patch; HL: Hearing level; SD: Standard deviation.

Table 3. Comparison of ABG values before and after CPP application

ABG (dB HL)	Before CPP		After CPP		p-value*
	Mean±SD	Median (Min-Max)	Mean±SD	Median (Min-Max)	
0.5 khz	22.91±6.22	25 (10–40)	3.43±5.52	0 (0–25)	0.001
1 khz	20.60±5.74	20 (10–30)	4.03±5.31	5 (0–25)	0.001
2 khz	16.64±5.39	15 (5–30)	3.43±4.46	5 (0–20)	0.001
4 khz	16.87±5.83	15 (5–30)	3.21±3.34	5 (0–15)	
p**	0.000		0.578		

*Wilcoxon Test; **Friedman Test. CPP: Cigarette paper patch; ABG: Air bone gap; HL: Hearing level; SD: Standard deviation.

lower than the pre-application values (p<0.001) (Table 2 and Fig. 1). The ABG values measured at 0.5 khz after CPP application were significantly higher than the values measured at 2 khz and 4 khz (p<0.001, p<0.001).

Before CPP application, AC PTA values were determined as 31.34±6.43 dB HL at 0.5khz, 29.03±6.23 dB HL at 1 khz, 26.19±4.36 dB HL at 2 khz, and 26.49±5.51 dB HL at 4 khz. After CPP application, the AC PTA values were determined as 11.72±7.15 dB HL at 0.5 khz, 11.42±7.22 dB HL at 1 khz, 11.87±6.33 dB HL at 2 khz, and 12.61±5.66 dB HL at 4 khz. ABG values measured at 1 khz were higher than those measured at 2 khz and 4 khz (p<0.01, p<0.05, respectively). No difference was found between the values at 0.5 khz and 1 khz, and those measured at 2 khz and 4 khz. There was no difference between ABG values at 0.5, 1, 2, and 4 khz after CPP application (p>0.05) (Table 3 and Fig. 2). Before CPP, ABG was determined as 22.91±6.22 dB HL at 0.5 kz, 20.60±5.74 dB HL at 1 khz, 16.64±5.39 dB HL at 2 khz, and 16.87±5.83 dB HL at 4 khz. After CPP application, ABG was determined as 433±5.52 dB HL at 0.5 khz, 4.03±5.31 dB HL at 1 khz, 3.43±4.46 dB HL at 2 khz and 3.21±3.34 dB HL at 4 khz.

A positive correlation was found between perforation dimension and pure tone average values (r=0.383, p<0.01) and AC PTA (r=0.342 p<0.01) values at 1 khz. The hearing gain average value obtained by examining the reduction rates in SSO

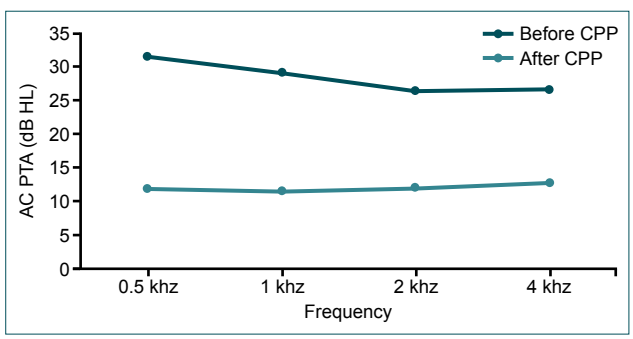

Figure 1. AC PTA measurements before and after CPP application. AC PTA: Air conduction pure tone average; CPP: Cigarette paper patch.

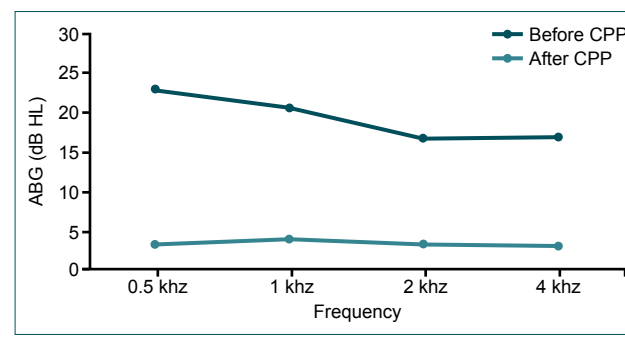

Figure 2. ABG values before and after CPP application. ABG: Air bone gap; CPP: Cigarette paper patch.

Table 4. Hearing gain at 0.5, 1, 2 and 4 khz

AC PTA (dB HL)	Before CPP		p-value*
	Mean±SD	Median (Min-Max)	
0.5 khz	-19.63±9.31	-20 (-40–5)	0.001
1 khz	-17.61±8.93	-20 (-40–0)	
2 khz	-14.33±7.22	-15 (-30–5)	
4 khz	-13.88±7.73	-15 (-35–0)	

*Friedman Test. AC PTA: Air conduction pure tone average; CPP: Cigarette paper patch; HL: Hearing level; SD: Standard deviation.

values was determined as 16.36±8.29 dB HL. This value was 19.63±9.31 dB HL at 0.5 khz, 17.61±8.93 dB HL at 1 khz, 14.33±7.22 at 2 khz, and 13.88±7.73 dB HL at 4 khz. The values at 0.5 khz were significantly higher than those at 2 khz and 4 khz (p<0.001, p<0.001, respectively) (Table 4).

DISCUSSION

TTMP is a problem encountered especially in developing countries and countries with low socioeconomic status.[9] TM is an important component of the tympano-osicular system, which provides sound transmission. TTMP can be caused for a variety of reasons, including explosions, blunt or penetrating injuries, and barotrauma. Sensorineural hearing loss may occur as a result of damage to round or oval window membranes due to perforations caused by explosions, whereas perforations associated with non-explosive trauma usually result in conductive hearing loss, and sometimes normal hearing functions can be seen.[10] According to the results of this study, patients with TTMP had conductive hearing loss of >20 dB at 0.5, 1, 2 and 4 khz. That this hearing loss was higher at 0.5 and 1 khz is consistent with the literature.[11]

TTMP can heal spontaneously in 70–90% of the cases, but this healing process can take longer than 1 month.[12] In addition to conductive hearing loss accompanied by symptoms such as fullness in the ear and tinnitus, the perforation can also lead to complications such as acute or chronic otitis media and cholesteatoma formation. Surgical treatment is inevitable when these complications develop.[10,13] In addition, when spontaneous closure does not occur, surgical treatment will be more invasive and costly. Therefore, office procedures that can be performed in the early period of TTMP are not only important for therapeutic purposes but also for the prevention of complications.[10] The results of this study reveal that CPP application after TTMP is a useful method for both perforation closure and improvement of hearing loss.

There are studies in literature showing the effects of paper patches and other alternative techniques and materials (silk patch, paper patch, and gelfoam patch) on perforation closure rates and hearing loss in the treatment of TTMP.[4,6,14] However, to the best of our knowledge, there have been no studies stating at what level this gain is relative to hearing frequencies. The results of the current study show that hearing loss caused by TTMP is greater at lower frequencies, and the application of cigarette paper in treatment provides more hearing gain at lower frequencies than at higher frequencies.

Paper patches can be used in cigarette paper form or different thin paper forms in TTMP repair. As CPP is readily available and quick to apply, it is a very successful treatment method with a minimum complication rate. It is also economically advantageous and has been reported to provide excellent hearing gain with rapid recovery rates.[2,5] In developing countries such as Turkey, CPP is quite widely used in the repair of small TTMP in particular. In a previous study, the closure rate was reported as 81.6% when no intervention was applied to TTMP. In the same study, the rate of closure was reported to be much higher with paper patch application (95.2%).[12] Lee et al.[2] reported the success rate of paper patch use as 84.6% and stated that there was no difference between paper patches and silk patches in terms of closure rates and otorrhea after application. Altuntaş et al.[5] reported that cigarette paper has a greater fibroblast activity enhancing effect than carbon paper because it has a more biocompatible and smooth surface. In the current study, the recovery rate was determined to be 91% 1 month after TTMP repair with CPP. According to the results of this study, the repair of TTMP with CPP was found to provide significant hearing gain at 0.5, 1, 2, and 4 khz. This gain was determined to be greater at low frequencies, especially at 0.5 and 1 khz. These results demonstrate that both post-procedure air conduction thresholds and ABG decreased significantly compared to the pre-application values.

The most important limitation of this study was that the TM localization of the perforation was not known. There is a need for further studies with larger patient series to show the effectiveness of cigarette paper application according to the localization of the perforation in TTMP.

Conclusion

TTMP causes conductive hearing loss, especially at low frequencies. CPP application in the early period is a simple and highly successful treatment method in these patients. It provides excellent levels of airway hearing gain, especially at low frequencies. Therefore, CPP application should be considered for patients who present early with TTMP.

Ethics Committee Approval: This study was approved by the Ankara Training and Research Hospital Ethics Committee (Date: 26.06.2020, Decision No: E-20).

Peer-review: Internally peer-reviewed.

Authorship Contributions: Concept: Ö.A.; Design: Ö.A.; Supervision: Ö.A.; Resource: S.K.K.; Materials: S.K.K.; Data: S.K.K.; Analysis: C.Ö.; Literature search: C.Ö.; Writing: Ö.A.; Critical revision: Z.K.

Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study has received no financial support.

REFERENCES

1. Yan K, Lv M, Xu E, Fan F, Lei Y, Liu W, et al. Effectiveness of patching traumatic eardrum perforations with lens cleaning paper via an otoscope. J Laryngol Otol 2017;131:805–8. [CrossRef]
2. Lee JH, Lee JS, Kim DK, Park CH, Lee HR. Clinical outcomes of silk patch in acute tympanic membrane perforation. Clin Exp Otorhinolaryngol 2015;8:117–22. [CrossRef]
3. Choi SH, Song HY, Song C. Fibrinogen-based collagen fleece graft myringoplasty for traumatic tympanic membrane perforation. J Audiol Otol 2016;20:139–45. [CrossRef]
4. Huang P, Zhang S, Gong X, Wang X, Lou ZH. Endoscopic observation of different repair patterns in human traumatic tympanic membrane perforations. Braz J Otorhinolaryngol 2018;84:545–52. [CrossRef]
5. Altuntaş EE, Sümer S. Biocompatibility evaluation of cigarette and carbon papers used in repair of traumatic tympanic membrane perforations: Experimental study. Eur Arch Otorhinolaryngol 2013;270:81–6. [CrossRef]
6. Eken M, Ates G, Sanlı A, Evren C, Bozkurt S. The effect of topical insulin application on the healing of acute tympanic membrane perforations: A histopathologic study. Eur Arch Otorhinolaryngol 2007;264:999–1002.
7. Upreti G. Office myringoplasty by chemical cauterization and paper patching: A prospective study. Int J Otorhinolaryngol Head Neck Surg 2019;5:4677. [CrossRef]
8. Çayır S, Mutlu H. Traumatic tympanic membrane perforation in children in the emergency department: Comparison of spontaneous closure and paper patch. Cureus 2020;12:e7697. [CrossRef]
9. Mourya A, Jain L, Jadia S, Qureshi S. A comparative study of various office procedures for the management of small to medium size tympanic membrane perforations. Indian J Otolaryngol Head Neck Surg 2018;70:351–4. [CrossRef]
10. Lou ZC, Lou ZH, Zhang QP. Traumatic tympanic membrane perforations: A study of etiology and factors affecting outcome. Am J Otolaryngol 2012;33:549–55. [CrossRef]
11. Dawood MR. Frequency dependence hearing loss evaluation in perforated tympanic membrane. Int Arch Otorhinolaryngol 2017;21:336–42.
12. Hanege FM, Karaca S, Kalcioglu MT, Tekin M. Comparing spontaneous closure and paper patching in traumatic tympanic membrane perforations. J Craniofac Surg 2018;29:1922–4. [CrossRef]
13. Yamazaki K, Ishijima K, Sato H. A clinical study of traumatic tympanic membrane perforation. Nihon Jibiinkoka Gakkai Kaiho 2010;113:679–86. [CrossRef]
14. Laidlaw DW, Costantino PD, Govindaraj S, Hiltzik DH, Catalano PJ. Tympanic membrane repair with a dermal allograft. Laryngoscope 2001;11:702–7. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Travmatik timpanik membran perforasyonlarının sigara kağıdı ile onarımının etkinliği

Dr. Özlem Akkoca, Dr. Selda Kargın Kaytez, Dr. Zeynep Kaptan, Dr. Coşkun Özdemir

Sağlık Bilimleri Üniversitesi, Ankara Eğitim ve Araştırma Hastanesi, Kulak Burun Boğaz Hastalıkları Kliniği, Ankara

AMAÇ: Bu çalışmada travmatik timpanik membran perforasyonunda (TTMP) sigara kağıdı yaması (SPP) ile onarımın; perforasyonun kapanması ve işitme fonksiyonları üzerindeki etkilerini değerlendirmek amaçlandı.

GEREÇ VE YÖNTEM: Kliniğimize Ocak 2015–2019 tarihleri arasında TTMP nedeni ile başvurmuş olan ve tedavide sigara kağıdı yaması (SPP) uygulanmış olan 61 olgu (67 kulak) geriye dönük olarak değerlendirildi. TTMP'nin boyutu; timpanik membranın (TM) tamamı %100 kabul edilerek sınıflandırıldı. %25'in altında olan perforasyonlar küçük, %25–%50 arasında olanlar orta %50 ve üzeri olan perforasyonlar ise büyük olarak değerlendirildi. Hastalara; SPP prosedüründen önce ve üç ay sonra odyolojik tetkik yapıldı. 0.5, 1, 2 ve 4 khz'de hava ve kemik yolu saf ses ortalamaları (SSO) ve hava kemik gap (ABG) ortalamaları karşılaştırıldı.

BULGULAR: Altmış yedi kulağın 20'sinde (%29.9) perforasyon küçük, 27'sinde (%40.2) orta, 20'sinde (%29.9) ise büyük idi. SPP öncesi hava yolu saf ses ortalaması (AC SSO) 28.26±5.63, kemik yolu saf ses ortalaması (BC SSO) 8.80±4.35, ABG 19.26±5.80 olarak bulundu. SPP sonrası AC SSO 11.90±6.59, BC SSO 8.29±4.05, ABG 14.10±4.66 olarak saptandı. SPP sonrası birinci ayda 61 kulakda (%91) TM'de iyileşme gerçekleştiği görüldü. Perforasyon boyutu ve kapanma oranları arasında istatistiksel olarak anlamlı fark bulunamadı ($p>0.05$). 0.5, 1, 2 ve 4 khz'de SPP sonrası AC SSO değerleri SPP öncesi AC SSO değerlerinden anlamlı düzeyde düşük bulundu ($p<0.001$). SPP sonrası 0.5 khz'de ölçülen ABG değerlerinin, hem 2 khz, hem de 4 khz değerlerine göre anlamlı düzeyde yüksek olduğu görüldü (sırasıyla $p<0.001$, $p<0.001$). Sigara kağıdı uygulaması sonrası SS0 değerlerindeki azalma miktarına bakıldığında, 0.5 khz'deki değerler hem 2 khz, hem de 4 khz'dekilere göre anlamlı düzeyde yüksek olarak saptandı (sırasıyla, $p<0.001$, $p<0.001$).

TARTIŞMA: TTMP'nin tedavisinde erken dönemde SPP uygulaması hem perforasyon kapanması hem de işitme kazancı bakımından etkili bir tedavi yöntemidir.

Anahtar sözcükler: İşitme kaybı; timpanik membran; timpanik membran perforasyonu; travma.

Ulus Travma Acil Cerrahi Derg 2022;28(2):217-221 doi: 10.14744/tjtes.2020.98968