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Evaluation of Traumatic Tympan Membrane Perforations

Ali Rıza Yamur [1,*] and Kürşat Murat Özcan [2]

[1] Department of Otorhinolaryngology, Head and Neck Surgery, Ankara Lokman Hekim University, Ankara 06930, Turkey
[2] Department of Otorhinolaryngology, Head and Neck Surgery, Ankara City Hospital, Ankara 06800, Turkey
* Correspondence: aryamur19@gmail.com

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Abstract: Background: Traumatic tympanic membrane (TM) perforations, although not life-threatening, can significantly impair quality of life by causing hearing loss, tinnitus, and discomfort. These perforations often result from blunt trauma, penetrating trauma, barotrauma, or blast trauma and may be managed either conservatively or surgically, depending on clinical characteristics. Methods: Patients with post-traumatic tympanic membrane perforations were retrospectively evaluated. Trauma type, time of hospital presentation post-trauma, otological complaints at presentation, perforation localization on the membrane, shape, size, and audiometric results were assessed. Results: A total of 48 ears from 47 patients with perforations were evaluated. Most patients (58.3%) presented to the hospital on the first day post-trauma, with initial audiometric evaluation conducted on the same day. Perforations were predominantly in the left ear (58%), anteroinferior quadrant (43.8%), medium-sized (72.9%), and oval/round-shaped (70.8%). Forty-two tympanic membranes underwent repair, while six perforations were managed conservatively. There was no significant difference in perforation healing between the repaired and non-repaired groups at one month post-assessment ($p = 1$); however, early repair showed statistically superior outcomes compared to late repair ($p = 0.01$). Conclusion: This study contributes to the literature by comprehensively evaluating clinical characteristics and treatment outcomes of patients with traumatic tympanic membrane perforations, based on single-center, single-surgeon experience. These findings may assist in determining treatment strategies for managing traumatic tympanic membrane perforations.

Keywords: Tympanic Membrane Perforation; Tympanic Trauma; Healing; Symptoms; Hearing Loss

1. Introduction

The tympanic membrane (TM), located between the external auditory canal and the middle ear, transmits sound waves from the external environment to the middle ear. The TM consists of three layers and due to its thin structure, various traumas can lead to perforations. Traumatic tympanic membrane perforation (TTMP) is a common otologic condition, but its true incidence is not well documented. Worldwide estimates suggest an incidence reported to be less than 1%, yet it is believed to be much higher [1]. TTMP can occur following blunt, penetrating, or explosive trauma to the ear drum. Depending on the size, small traumatic perforations often heal spontaneously, while in some cases the perforation may remain open or heal with only a thin membrane. Studies in the literature report spontaneous healing rates of TTMP ranging from 48% to 94% [2–5]. If healing is delayed or does not occur, it can lead to chronic perforation requiring surgical intervention to close the TM perforation. TTMP is not life-threatening, but if healing is incomplete, it can cause bothersome symptoms such as pain, ringing/tinnitus, hearing loss, and dizziness, and may increase the risk of otitis media. Therefore, research in the literature highlights various materials and molecules used to expedite or facilitate the healing process in TTMP cases [6–8].

This study aims to analyze the clinical epidemiological characteristics, etiological factors, treatment approaches, and outcomes of patients presenting with TTMP at a tertiary otolaryngology clinic. Additionally, it seeks to analyze the relationships between parameters assessed with TTMP and interpret the results in the context of current literature.

2. Material and Methods

2.1. Ethical Standards

This study was conducted in a tertiary care hospital after approval of the study protocol by the Institutional Ethics Committee (decree no: E1-20-384).

2.2. Study Population

Medical archive records of patients diagnosed with traumatic tympanic membrane perforation (TTMP) in the Ear Nose Throat (ENT) outpatient clinic between February 2016 and February 2020 were retrospectively evaluated. A total of 47 patients aged 18–65 years, diagnosed with TTMP based on medical history, physical examination, and otoscopic findings by the same ENT physician to ensure standardization of diagnosis and treatment approaches, were included in the study. One patient contributed both ears to the study due to traumatic perforation in both ears. Cases developing TTMP due to blunt, penetrating, barotrauma, or blast trauma were included in the study, while patients with TMP without trauma, a positive history of chronic otitis media, or temporal bone fracture and/or ossicular chain dislocation along with TMP were not included.

Patients' electronic records were reviewed to record demographic data, the affected ear in TTMP, type of trauma, time of hospital presentation post-trauma, otological complaints such as hearing loss, tinnitus, and presence of otalgia at presentation, localization of perforation on the membrane, shape of perforation (round/oval, slit-like, irregular), perforation size, and audiometry results.

Types of trauma leading to TTMP were classified as blunt (various blows to the ear during slapping, fighting, ball hitting, etc.), penetrating (cotton swab, toothpick, knitting needle, etc.), barotrauma (pressure changes in the ear caused by airplane flights, closing the external auditory canal with the palm of the hand, blowing the nose, etc.), and blast trauma (due to explosion). Perforation size was classified into three groups according to the method used by Lou et al.: small (<1/8 of the eardrum), medium (1/8–1/4 of the eardrum), and large (>1/4 of the eardrum) [9].

Upon retrospective evaluation of hospital records, the standard treatment approach for cases diagnosed with TTMP involves the following procedure: application of 4% xylocaine-soaked cotton on the tympanic membrane under otomicroscopy for 5 min, followed by de-epithelialization of the perforation edges and application of 30% trichloroacetic acid to the residual tympanic membrane edges. A suitable-sized cigarette paper is then applied to completely cover the perforation.

Out of 48 ears included in the assessment, 87.5% (n = 42) underwent perforation repair on the day of presentation (Group 1), while 12.5% (n = 6) declined intervention and were managed conservatively (Group 2) for spontaneous healing.

The condition of the tympanic membranes at initial presentation and one-month follow-up examinations, along with pure tone audiometric (PTA) evaluations, were compared retrospectively. PTA values were calculated by averaging air and bone conduction threshold measurements at 500, 1000, 2000, and 4000 Hz frequencies. The difference between air and bone conduction averages was considered as the air-bone gap (ABG).

The impact of patient age, gender, time since trauma, perforation morphology, and type of trauma on TTMP healing, repair success, and audiometric outcomes was evaluated. Furthermore, patients in Groups 1 and 2 were compared regarding perforation healing and audiologic outcomes.

2.3. Statistical Analysis

All analyses were performed using the SPSS Statistics for Windows, version 25.0 (IBM Corp, Armonk, NY, USA). Descriptive statistics were expressed as mean ± SD or median (minimum-maximum) for continuous variables and as case numbers and percentage for nominal variables. Differences between the groups were

compared by Student's T test or Chi-square as appropriate. All variables used in the models were added at the same level. A *p*-value of ≤ 0.05 was considered statistically significant.

3. Results

3.1. Analysis of Demographic Data and General Evaluation Parameters

Of the 47 patients included in the study, 66% (n = 32) were female and 34% (n = 15) were male, with a median age of 32 years (Min-Max: 18–64). The mean time from trauma to hospital admission was 1.8 ± 2 days.

General findings regarding the data used for patients with TTMP are presented in **Table 1**.

Table 1. The data used in the study of patients with TTMP.

Form of Trauma %(N)	Blunt 66.7 (n = 32)	Open hand %56 (n = 18) Ball hit %6 (n = 2) Unqualified blow to the head %38 (n = 12)
	Penetrating 18.8 (n = 9)	Cotton swab %67 (n = 6) Toothpick %22 (n = 2) Knitting needle %11 (n = 1)
	Barotrauma 8.3 (n = 4)	Pressure with palm %50 (n = 2) Nose blowing %25 (n = 1) Plane travel %25 (n = 1)
	Blast 6.3 (n = 3)	Bomb explosion 100.0 (n = 3)
Time to Apply to The Hospital	1. day	%58.3 (n = 27)
	2. day	%31.3 (n = 15)
	3. day	%4.2 (n = 2)
	4. day	%2.1 (n = 1)
	5. day	%2.1 (n = 1)
	14. day	%2.1 (n = 1)
Symptoms	Ringing/tinnitus	%64.6 (n = 31)
	Otalgia	%62.5 (n = 30)
	Hearing loss	%58.3 (n = 28)
Affected Ear	Left ear	%58 (n = 28)
	Right ear	%42 (n = 20)
Localization of Perforation	Anteroinferior	%43.8 (n = 21)
	Posteroinferior	%35.4 (n = 17)
	Anterosüperior	%10.4 (n = 5)
	Posterosüperior	%6.3 (n = 3)
	Bilateral perforated ear (posteroinferior and posterosuperior in the right ear, anteroinferior and posteroinferior in the left ear)	%4.2 (n = 2)
Perforation Shape	Round/oval	% 70.8 (n = 34)
	Slit-like	%16.7 (n = 8)
	İrregular	%12.5 (n = 6)
Perforation Size	Small	%14.6 (n = 7)
	Medium	%72.9 (n = 35)
	Large	%12.5 (n = 6)

3.2. Analysis of Audiological Evaluation Results

In the initial SSO evaluation conducted during patients' first visits, the median value of air conduction pure tone thresholds was 19 dB (Min-max: 8–51 dB), and the median value of ABG was 12.5 dB (Min-max: 2–28 dB).

Table 2 displays the average air conduction thresholds and ABG values detected during the initial visit and one month later for patients in Group 1 and Group 2. Significant differences were observed when comparing ABG values in Group 1 patients during their initial visit and one month post-repair ($p < 0.001$). Similarly, statistically significant differences were found in Group 2 patients as well ($p = 0.002$).

Table 2. Average air conduction pure tone threshold and air bone conduction gap values in pure tone audiometry.

	Airway Threshold in First PTA (dB)	ABG in First PTA (dB)	Airway Pure Tone Threshold in 1st Month PTA (dB)	ABG in 1st Month PTA (dB)
Group 1 (n = 42)	22.8 ± 10	12.6 ± 4.2	13.8 ± 7.6	5.1 ± 3.7
Group 2 (n = 6)	16.6 ± 3.9	12.3 ± 2.1	10.0 ± 4.0	4.5 ± 1.6

TTMP: Traumatic tympanic membrane perforation

PTA: Pure tone audiometry

ABG: Air bone gap

At the end of the first month, comparing patients from Group 1 and Group 2 with intact TM regarding PTA results, the mean ABG value was 3.9 ± 2.4 dB in Group 1 and 5 ± 1.2 dB in Group 2. There was no statistically significant difference between the mean ABG values of both groups ($p > 0.05$).

The relationship between the type of trauma causing TTMP and PTA results was evaluated. It was found that there was no statistically significant relationship between the type of trauma and the mean ABG value detected during the initial visit and one month later, as well as between the improvement in ABG (difference between initial ABG and ABG at one month) and the type of trauma ($p > 0.05$, p = 0.55; $p > 0.05$, $p = 0.56$; $p > 0.05$, $p = 0.1$).

3.3. Analysis of the Relationship between Tympanic Membrane Perforation Repair and Evaluated Parameters

In Group 1, one month after otomicroscopic examination, TM was intact in 83.5% (n = 35) and perforated in 16.5% (n = 7) of patients; in Group 2, TM was intact in 83.5% (n = 5) and perforated in 16.5% (n = 1) of patients. There was no statistically significant difference in TM healing between the two groups ($p > 0.05$).

The effect of trauma type on TMP healing was evaluated; at one-month follow-up, 81.3% (n = 26) of patients with blunt trauma and 87.5% (n = 14) of those with other traumas had intact TM. The type of trauma did not lead to statistically significant differences in healing ($p = 0.584$).

In Group 1, when evaluating the effect of trauma type and perforation shape on TMP healing, 81.5% (n = 22) with blunt trauma, 100% (n = 9) with penetrating trauma, 100% (n = 3) with blast trauma, and 33.3% (n = 1) with barotrauma had intact TM after repair. Regarding perforation shape, 75.9% (n = 22) of round/oval perforations, 100% (n = 8) of slit perforations, and 100% (n = 5) of irregular perforations were found to have intact TM one month post-repair. There were no statistically significant differences in the success of TMP repair among trauma types and perforation shapes (p = 0.09, p = 0.28).

Additionally, when evaluating the effect of perforation localization and size on TMP healing in Group 1, no statistically significant differences were found (p = 0.36, p = 0.26).

One month after repair, intact tympanic membranes were observed in 80% of male patients and 85.2% of female patients in Group 1. There was no statistically significant difference in repair success between genders (p = 0.67).

The average improvement in ABG was 8.1±6.2 in males and 7.3±3.7 in females; there was no statistically significant difference in ABG improvement between genders (p = 0.59).

Considering the time of presentation after trauma, 87.2% (n = 34) of patients presenting within the first 3 days and 33.3% (n = 1) of those presenting after 3 days had intact TM after TMP repair. There was a statistically significant difference in TMP repair success based on the time of presentation (p = 0.01).

4. Discussion

There are numerous studies in the literature evaluating various aspects of TTMP. These studies indicate that TTMP causes symptoms such as hearing loss, tinnitus, ear pain, and dizziness, which reduce quality of life rather than posing a life-threatening condition. There can be several factors in the etiology of TTMP. Due to the impact on quality of life and the anxiety it can cause in patients, many of them seek consultation with an ENT specialist. In our study, we aimed to evaluate the potential relationships between the epidemiological and clinical characteristics of 47 patients followed by a single physician with a diagnosis of TTMP, alongside the success of treatment approaches, in light of the literature. Depending on the socio-cultural structure of the community, the mechanism of trauma in TMP varies. For instance, when cases are evaluated based on the most common type of trauma causing TTMP, it is noted that in the United States, 60.9% is due to foreign bodies in the ear, whereas in China, Pakistan, and Germany (with percentages of 85%, 70.2%, and 37.4%, respectively), it is due to slap injuries [9–12]. Similarly to some findings in the literature, in our study, the most common cause of TTMP was blunt trauma due to a slap with an open hand.

As a natural consequence of activities involving trauma and violence being more frequent among men, TTMP is observed more commonly in the male gender [10,13,14]. In contrast to the literature, in our study, the majority of patients (66%) consisted of female cases. This difference can be explained as a result of socio-cultural reasons, particularly in developing societies where violence against women may be more prevalent. The relatively lower socio-cultural and economic level of our study conducted in a single center compared to the general population also supports this notion. Our study reflects the patient profile from a single center, and these results should not be interpreted to encompass the general population. While the single-center, single-physician experience is an important aspect of our study in some respects, it also presents a significant limitation in interpreting the results. However, we believe that in the future, similar results obtained through more comprehensive and multicenter studies could contribute to the literature from a sociological perspective.

Studies evaluating the times patients present to the hospital and the timing of hearing assessments following TTMP trauma are also found in the literature [14,15]. These studies generally report that hearing assessment is typically performed by the 4th day, and patients usually seek medical attention within 3 days. In our study, the times for hospital presentation and hearing assessments for evaluated patients are similar to the results in the literature. Since TTMP negatively impacts quality of life, patients typically seek medical attention early on.

Perforations of the TM can spontaneously heal under various circumstances without accompanying negative factors. Wahid et al. reported that more than 90% of tympanic membrane perforations can heal spontaneously under appropriate conditions [11]. Lou et al. noted that within the first 4 weeks, over 70% of small to medium-sized tympanic membrane perforations and 25% of larger perforations completely healed [9]. They also suggested that the size of the perforation might influence the average healing time. Similarly, in our study, both spontaneously healed and surgically repaired cases showed intact TMs in 83.5% of cases during the first month follow-up. Branica et al. reported that in blast trauma cases, repairing the TM within the first 3 days after TMP emergence led to better outcomes compared to delayed intervention [16]. Our study's findings similarly indicate that early repair within 3 days results in higher treatment success. Due to the absence of a standardized treatment procedure for TMP cases, a conservative “wait and see" approach may be appropriate, considering our results and those of similar studies in the literature. However, if spontaneous healing does not commence within the first few days following TMP, alternative treatment options should be considered. As time from TMP-causing trauma increases, both the spontaneous healing potential and the success rates of other treatments decrease. In conclusion, we believe that close clinical monitoring and early intervention are crucial for successful clinical outcomes in patients with TTMP.

In the literature, it is noted that patients with TTMP most commonly present to the hospital with complaints of hearing loss and ear fullness. Additionally, they may experience symptoms such as vertigo, dizziness, and otorrhagia (bleeding from the ear) [11,13,15]. In our study, while tinnitus/ringing in the ear was the most commonly reported complaint consistent with the literature, none of our patients exhibited symptoms of vertigo, dizziness, or bleeding from the ear.

Trauma mostly occurs due to violent actions. Generally, right-hand dominance is prevalent in humans. As a natural consequence of this, perforations are expected to be more common in the left ear. Consistent with studies in the literature regarding TTMP, our cases also show that perforations, especially in the anteroinferior quadrant and left ear, are more frequent [11,14,17].

In cases of TTMP, the most common irregular perforation shape is often observed, whereas in our cases, oval/round perforations were more frequent [18]. In our literature review, we could not find a study comparing the shape of perforations with healing outcomes and pure tone audiogram findings in TTMP cases. In our study, when the shape of perforation was statistically evaluated with healing outcomes and improvement in ABG, no significant difference was found. However, it is known that the location and size of the perforation are crucial for hearing. Sogebi et al. reported conductive hearing loss in TTMP patients with significant improvement in hearing parameters over time [15]. Branica et al. indicated the occurrence of conductive hearing loss in TTMP cases and recommended intervention within the first 72 h post-trauma for optimal hearing outcomes [16]. While an association between these factors and hearing is expected in TTMP cases, our study may not have reflected these differences due to its small sample size. Additionally, determining the size of perforation secondary to trauma can be challenging, especially in irregularly shaped perforations. Therefore, we believe it would be premature to make definitive conclusions on this matter without evaluating larger case series.

In conclusion, the results obtained from our study are generally consistent with findings in the literature. The strength of our study undoubtedly lies in reflecting the experience of a single center and a single physician, minimizing potential variations in patient assessment and treatment processes. In our study, we also evaluated the impact of various parameters on hearing in cases of TTMP, which differs from what is reported in the literature. However, due to our limited sample size, the statistical relationship of these parameters could not be clearly established. Therefore, we believe that future studies encompassing larger and multi-center case series investigating relationships such as the shape, size of perforation, and type of trauma with hearing outcomes will be beneficial. Additionally, future research should also consider the potential effects of spontaneous recovery and/or different types of repairs through broader and multi-center studies, which could contribute to establishing standard treatment protocols for TTMP cases. In conclusion, while single-center, single-physician experiences are valuable, it is undeniable that there is a need for larger studies covering different dimensions of TTMP in the future.

Author Contributions

Conceptualization, A.R.Y. and K.M.Ö.; methodology, A.R.Y and K.M.Ö.; software, A.R.Y. and K.M.Ö.; validation, A.R.Y. and K.M.Ö.; formal analysis, A.R.Y. and K.M.Ö.; investigation, A.R.Y. and K.M.Ö.; resources, A.R.Y. and K.M.Ö.; data curation, A.R.Y. and K.M.Ö.; writing—original draft preparation, A.R.Y. and K.M.Ö.; writing—review and editing, A.R.Y. and K.M.Ö.; visualization, A.R.Y. and K.M.Ö.; supervision, A.R.Y. and K.M.Ö..; project administration, A.R.Y. and K.M.Ö. All authors have read and agreed to the published version of the manuscript

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Ethics Committee of Ankara Bilkent City Hospital (protocol code E1-20-384 and date of approval: 30.04.2020)

Informed Consent Statement

Not applicable

Data Availability Statement

Data available on reasonable request

Conflicts of Interest

The authors declare no conflict of interest.

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