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Original Article

Evaluation of Patients with Post-Traumatic Hearing Loss: A Retrospective Review of 506 Cases

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OBJECTIVES: The purpose of the study is to evaluate the audiological, radiological, and examination findings of patients who have been treated for hearing loss (HL) due to head trauma and evaluated in terms of causality to reveal current data, and to highlight the steps to be taken.

METHODS: We retrospectively reviewed the reports of cases that had applied for disability with HL due to head injury and had been evaluated by the Forensic Medicine Institute between January 01, 2009 and January 01, 2019.

RESULTS: Of the total cases of head trauma, 52.42% were not vehicle-related, and cases were observed to be concentrated in the age range of 19-40 (55.92%; $n = 283$). Although otorrhagia/otorrhea was the most common finding in all types of trauma, TM perforation was the most common finding in blast-type injuries. While the rate of newly developed unilateral HL was 84.2%, 72.7% of the patients had sensorineural hearing loss (SNHL) . Temporal bone fractures were detected in 59.3% of the cases, and 60.2% of them were of the longitudinal type. Facial paralysis (FP) was detected in 28.6% of the cases, and there was no statistically significant difference between the groups in terms of HL compared to those without FP. Other nerve palsy was detected in 4.9% of the cases, and N. Abducens paralysis was the most common.

CONCLUSION: Accompanying intracranial nerve injury, temporal fracture, and intracranial pathologies are considerably high in patients who develop HL following head trauma. The first examination requires a multidisciplinary approach to guide future disability applications.

KEYWORDS: Post-traumatic hearing loss, temporal bone fracture, FP, cranial nerve palsy

INTRODUCTION

In addition to being a major cause of morbidity and mortality, head injuries have an important place in emergency care admission due to their annual incidence of up to 5%.[1] The most common causes are falling, crashing into a blunt object, and motor vehicle accidents.[2]

In cases with traumatic brain injury, permanent physical and sensory disabilities, including hearing loss (HL), increase to very high rates. It has been reported that patients with traumatic brain injury have a 2125-fold higher risk of developing HL.[3]

In traumas affecting the temporal bone, complications such as HL, facial nerve paralysis, cerebrospinal fluid (CSF) leakage, and vestibular disorders may be observed due to damage to the inner and middle ear structures in this region.[4] If there is a temporal bone fracture, hearing loss (HL) can be explained by the mechanical damage to the middle and inner ear structures that occurs relative to the fracture line.[5,6] According to the more preferred classification of temporal bone fractures in current literature, rates of sensorineural hearing loss (SNHL), CSF leakage, and facial nerve palsy are observed to be higher in fractures with otic capsule damage.[7,8] However, even without temporal bone fracture, HL may be observed due to damage in peripheral or central auditory pathways.[9]

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Although HL may be seen in the acute period, it may occur in the late period as well, especially in case of SNHL. Therefore, the audiometric follow-up period of patients with trauma becomes important. On the other hand, as head traumas with HL may be accompanied by other cranial nerve injuries and intracranial pathologies, these parameters must be evaluated in the patient's examination.

The aim of our study is to evaluate the audiological, radiological, and examination findings of patients who have been sued for HL due to head injury and evaluated, to reveal the current data, and to emphasize the steps that should be applied in the first evaluation post-trauma.

MATERIALS AND METHODS

The cases were evaluated by a board consisting of a radiologist, neurologist, otolaryngologist, and forensic expert. In the files, post-traumatic examinations, hospitalization documents, and patients' progress were examined. General, ENT, and neurological examinations of the patients were performed at the institution. Tympanogram, pure-audio audiogram, and if necessary, ABR examinations were repeated in the audiology department of the institution. Radiological images in the file were reevaluated by both an otorhinolaryngologist and a radiologist. Intracranial pathologies were referred to the neurology member and the findings were noted.

Patients who had HL which could not be associated with head trauma, those who had HL below 35 dB, and those without a disability were not included in the study.

Five hundred 6 cases of HL linked to head trauma were examined in terms of age, gender, cause of trauma, findings of the first examination of the ear, the time between trauma and first pure-tone audiometry test, side of HL, degree and type, type of temporal bone fracture, presence of facial paralysis (FP) and other cranial nerve paralysis, audiovestibular symptoms, and intracranial pathologies.

The causes of trauma were categorized as traffic accident inside vehicle (TAIV), traffic accident outside vehicle (TAOV), occupational accidents (falling from height, object hit on the head, jamning of the head), blast effect (explosion/sudden exposure to loud sound) and others (falling from height, assault, gunshot wounds etc.).

The duration of time between occurence of trauma and the first audiometry test was noted; it was categorized as early period if it was 15 days or earlier; and late period if more than 15 days had elapsed.

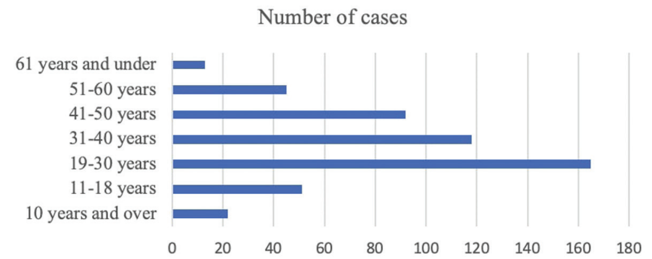

Figure 1. Distribution of cases according to age range.

RESULTS

Of the 506 cases included in the study, 402 (79.4%) of them were men and 104 (20.6%) were women. The mean age was 32.9 ± 13.9 years (min 4; max 81; average age of females 33.73 ± 13.9; average age of males 32.71 ± 13.9). An analysis by age groups showed a greater concentration of trauma cases in the 19-40 age range (55.92%; $n = 283$) (Figure 1). An examination of the cause of trauma showed cases distributed as follows: 132 (26.1%) were due to a traffic accident inside the vehicle (TAIV); 256 (52.4%) due to traffic accidents outside the vehicle (TAOV); 58 (11.5%) cases of occupational accidents; 14 (2.8%) due to the effect of a blast; and 37 (7.3%) due to other causes of trauma. It was observed that the applications related to TAOV were more in all age ranges.

An evaluation of the trauma cases with regard to the mean age showed that while the mean age of the patients who had TAIV was the highest, at 34.80 ± 12.3 years, that of the patients who had TAOV was the lowest, at 31.61 ± 15.19 years. The difference between the groups was not statistically significant. ($P = .080$).

The primary examination of the trauma cases revealed that otorrhagia/otorrhea was the most common, both isolated ($n = 159$, 31.4%) and accompanied by other findings. A comparison of the first otoscopic examination findings and the causes of trauma showed that although otorrhagia/otorrhea was the most common occurrence in all types of trauma, TM perforation was the most common finding in blast-type injuries. No findings were detected in the examination of 71 (14.0%) cases (Table 1).

Regarding the time of the first audiometry test, we found that the number of cases in the early group was 72 (14.2%), and in the late group it was 434 (85.8%) (average test time 26.40 ± 26.33 months).

HL was unilateral in 348 cases and bilateral in 158 cases. On the other hand, 78 had unilateral HL preceding trauma, and 80 cases had

Table 1. The Relationship Between Case Findings of Otoscopic Examination and the Cause of Trauma

	Causes of Trauma				
Otoscopic Examination Findings	**TAIV (%)**	**TAOV (%)**	**Occupational Accidents (%)**	**Blast (%)**	**Others (%)**
Hemotympanum	11.84	5.67	7.14	0.0	0.0
TM perforation	5.26	3.55	7.14	57.14	21.74
EAC laceration	10.53	4.96	3.57	14.29	17.39
Otorrhagia/Otorrhea	51.32	63.83	75.0	0.0	39.13
Multiple findings	14.47	21.99	3.57	14.29	21.74
Others	6.58	0.0	3.57	14.29	0.0

TAIV, traffic accidents ınside vehicle; TAOV, traffic accidents outside vehicle; TM, tympanic membrane; EAC, external auditory canal.

bilateral HL after trauma. Therefore, the rate of the newly developing unilateral HL cases was determined as 84.2%.

An examination of the types of HL detected in the cases revealed that SNHL was found in 72.7% of the cases, mixed HL in 18.6%, and conductive HL (CHL) in 8.7%.

An analysis of the relationship between HL and the first examination findings revealed that while there were usually first examination findings present in cases with HL, cases without findings in the first examination were more common among patients with SNHL. The difference between the groups was not found statistically significant. ($P = .080$).

The average of bone conduction threshold values of all cases was 46.42 ± 22.60 dBL; the average of air conduction threshold values was determined as 48.86 ± 23.88 dBL.

Examinations of the temporal bone revealed no fractures in 206 (40.7%) cases. Temporal bone fractures were longitudinal in 181 (35.8%) of the cases, transverse in 62 (12.2%) cases, and of a mixed type in 57 (11.3%) cases (Figure 2).

While the mean bone–air threshold values were slightly low in cases without temporal fracture, the mean threshold value was found to be higher in patients with transverse-type temporal bone fracture.

In patients without temporal bone fracture, the most frequent type of HL was SNHL at 73.8%, and the least common was CHL at 10.2% (Table 2).

FP was detected in 145 (28.6%) cases. While the paralysis was generally peripheral, 7 cases had permanent central FP. While the paralysis in 17.2% of the cases was transient, it was found to be permanent in 82.82% of them.

While 67.59% of the cases with FP were found to have SNHL, only 6.9% of them had CHL. When these groups were compared with those without FP, the statistical analysis showed that the difference between the groups was not significant ($P = .490$).

Other cranial nerve palsies were detected in 25 (4.9%) cases, and N. Abducens paralysis was the most common palsy with 20 cases

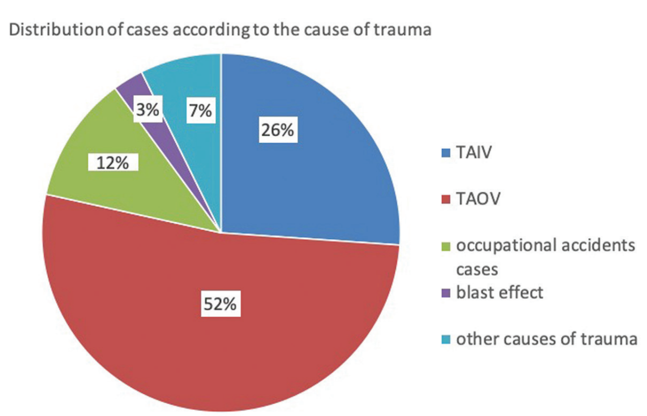

Figure 2. Distribution of the temporal bone fractures.

Table 2. The Distribution of Types of HL in Patients Without Temporal Bone Fracture

	No Temporal Fracture	
	N	**%**
SNHL	152	73.8
CHL	21	10.2
Mixed	33	16
Total	206	100

SNHL, sensorineural HL; CHL, conductive hearing loss.

(in 9 cases with other cranial palsies). N. Oculomotorius palsy was detected in 10 cases (5 of them isolated), N. Trochlearis palsy in 8 cases (all with other cranial palsies).

An examination of the vestibulocochlear symptoms revealed nystagmus and similar vestibular symptoms in 52 (10.3%) cases, tinnitus in 17 (3.4%) cases, and mixed symptoms in 5 (1%) cases. An analysis of the relationship between additional symptoms detected in the cases based on the types of HL revealed that overall, vestibular symptoms were more common in all types of HL. The difference between the groups was not statistically significant ($P = .758$).

While at least one intracranial finding was detected in 370 (73.1%) cases, the number of cases accompanied by multiple findings was 206 (40.7%). We identified 138 cases with parenchymal injury, 119 cases with sub-arachnoid hemorrhage, 115 cases with epidural hematoma, 106 with subdural hematoma, 103 cases with pneumocephaly, 58 cases with long-term malaic changes, 18 cases with contrecoup trauma/concussion in the cochlea, and 5 cases with intraventricular bleeding. In the 18 cases with contrecoup trauma / concussion in the cochlea, HL developed on the opposite side of the ear that was traumatized. No intracranial pathology was detected in 13 of the cases exposed to blast-type trauma, while multiple intracranial pathologies were detected in 1 case. An examination of the relationship between intracranial pathologies and unilateral or bilateral HL revealed that in patients with intracranial pathology, the rate of cases with unilateral loss was 83.24%, while the rate of cases with bilateral loss was 16.76%. No statistically significant difference was found between the groups with and without intracranial pathology with respect to HL ($P = .333$).

DISCUSSION

Disability applications due to head trauma are among the top 4 reasons, following applications related to lower-extremity injuries.[10–12] HL after head trauma is an expected situation due to the location of anatomical structures and conduction pathways related to hearing.

While the frequency of head trauma varies by gender, it is more common in men. While in the previous study by Podoshin L. et al., in which they examined cases which developed HL after head trauma, the rate of male cases was 77.5% (n = 307); in a more recent, similar study by Shangkuan WC. et al., the proportion was found to be decreased, at 61.63% (n = 340.972).[3,13] In the study investigating the differences between the results of head trauma cases in 46 high and low-income countries, de Silva MR. et al. reported that the rate of male cases in high-income countries was 79% (n = 1.667) and the rate of male cases in low-income countries was 82% ($n = 5580$).[14] In our study,79.4% of the cases were male, which corresponds to findings of other studies on head trauma that males are more frequently injured. We think that the reason for this is that males commute more in traffic for their work, and are involved in lines of business that require excessive physical strength, and in more aggressive activities that pose greater risk.

An examination of the age range of trauma cases revealed that age in the majority of cases was between 19-30 (32.6%) and 31-40 (23.3%). In their study of cases of head trauma, Işık HS. et al. reported that most cases involved those between the ages of 21-40 ($n = 395$, 41.4%). The results of our study are similar to those in the literature, with respect to the prevalance of cases in the young and middle-aged groups.[3,14,15]

In their study on the epidemiology of head trauma, Ökten et al. reported that traffic accidents (50.6%) were the most common cause of trauma, while the second most frequent cause was falls (35.2%).[16] In their study on HL following head injury, Shangkuan WC. et al. and Işık HS. et al. reported that traffic accidents occupied the first place with a rate of 62.55-75%, followed by falling from a height (12.5-19.05%).[3,15] Similarly, in our study, it was determined that TAOVs were at the forefront, with 52.4%.

The findings of post-traumatic ear examinations were studied, and the distribution was similar to that reported in the literature. The most common finding was otorrhagia / otorrhea.[17–20] Proportionally fewer otoscopic findings were detected in patients with SNHL (~ 3.09 : 1). It is thought that the reason for this difference is that the pathology that causes SNHL, is located in the inner ear and is retrocochlear. TM perforation is more commmon in blast-type traumas than in traumas with other causes. In our study, while TM perforation constituted 7.27% of all findings, it was found to constitute 57.14% of findings blast-type injuries alone. The literature reveals that in the various studies conducted for military personnel, it was found that while the prevalence of TM perforation was between 2-7% regardless of the type of trauma, this rate was reported between 12-50% in those exposed to blast injury alone.[21–23]

Analysis of our findings with regard to the the period until the first audiometric evaluation revealed that CHL and mixed HL cases that were tested in the early period were found to be proportionally higher than in the late period. We think that this is due to the fact that CHL and mixed HL show more findings in terms of audiology. In the literature, it was reported that the difference between the groups in terms of the risk of HL increased significantly after the 6th month in patients with and without head trauma. It is thought that the long hospital stay and the SNHL in late period associated with late degeneration of hearing pathways after head trauma play a role in causing this difference.[3]

While unilateral HL was observed in 84.19% of cases, bilateral HL was most common in blast-type traumas. Damage of cochlear hair cells caused by shock (pressure) waves occurring in blast-type trauma affect both ears and this explains the occurrence of bilateral HL.[24,25] Therefore, it is thought that one of the causes of bilateral HL developed after TAIV may be the peak sound pressure caused by the opening of the airbag.[26,27]

In studies in the literature, diffuse axonal damage or coup-contrecoup contusion has been reported due to whipping movement (acceleration–deceleration, rotational movement) at the time of the accident. It has been reported that intracranial contusions are more common in the lower part of the frontal region and anterior part of the temporal region, and diffuse axonal damage is more frequently detected in the cerebral white matter, corpus callosum, and upper brain stem.[28]

The fact that the type of HL that develops after trauma is predominantly SNHL (72.7%) seems to be compatible with the literature.[3,13] In a study on the frequency of ENT pathologies that admitted to Health Boards in our country, when hearing losses due to chronic otitis media were excluded from the evaluation, the results of were found to be similar to our study.[29]

While no temporal bone fracture was detected in 40.7% of the cases, 60.4% of the fractures were detected as longitudinal, 20.8% as transverse, and 18.8% as mixed temporal bone fractures. Amin Z. et al. reported the distribution of temporal bone fractures in patients with head trauma as follows: 67.4% were longitudinal, 8.7% were transverse, 13.0% were mixed, and 10.9% were oblique fractures.[30] Wysocki J. et al. and Jhonson F. et al. reported that longitudinal fractures were seen at the rate of 80-90%, transverse fractures at 10-20%, and mixed fractures at 7-10%.[19,31] The results of our study were found similar to the results in the literature.[17–20]

Approximately 16% of the cases of FP are caused by trauma, and temporal bone traumas are the most common cause. Considering studies on temporal bone fracture, FP was detected in 7-34.3% of the cases; similarly in our study, FP was detected in 28.6% of the cases.[32,33]

In our study, N. Oculomotorius (III), N. Trochlearis (IV), and N. Abducens paralysis were detected in addition to FP. Sixth cranial nerve palsy was the most common, and all the fourth cranial nerve palsies were accompanied by other nerve palsies. There are no studies in the literature evaluating cranial nerve palsy in head injuries with HL. Dhaliwal et al. reported that the 3rd nerve paralysis is associated with more severe traumas and the 6th nerve paralysis can be seen even in mild traumas.[34] Similarly, in their study with 49 patients showing that nerve paralysis may develop in mild head injuries involving the cranial nerve, Coello et al. reported CN VI paralysis in 11 cases, and CN III And CN IV paralysis in 7 cases.[35] These data demonstrate the importance of other cranial nerve examinations in trauma patients presenting with HL.

Vestibular symptoms and tinnitus were more common in patients with SNHL. According to the literature review, we think that the more frequent presentation of all symptoms in SNHL can be explained by post-traumatic labyrinthine contusion.[36,37] Likewise, studies, have reported that HL can be detected in 26.9% of cases without traumatic intracranial pathology and it was thought that labyrinthine contusion and injury to the organ of Corti played a role.[36,38,39] In 18 cases, HL was observed on the opposite side of the traumatized ear. It is stated in the literature that labyrinthine contusion is involved in the development of HL in such cases.[40,41]

CONCLUSION

The first examination and subsequent examinations should be planned, considering that the development of HL following head trauma may appear and regress immediately, or may occur over time. We think that further studies are needed to standardize how long after the trauma, the final state examination should be done for applications for disability due to HL following head trauma. In addition, in patients with HL after the head injury, accompanying intracranial nerve damage, temporal fracture, and intracranial pathologies are quite high depending on the type of trauma. Therefore, the first examination after trauma requires a multidisciplinary approach to guide future disability assessment.

Ethics Committee Approval: In our study, head trauma cases evaluated by the 3rd Specialization Board of the Forensic Medicine Institute and whose reports were dated between January 1, 2009 and January 1, 2019 were reviewed retrospectively. Approval was obtained from the local ethics committee for the study (reference number: 2189509/2019/408).

Informed Consent: N/A.

Peer Review: Externally peer-reviewed.

Author Contributions: Concept – M.Y.A., K.S.O., H.A.; Design – M.Y.A., K.S.O., Z.O.; Supervision- K.S.O., E.K.O.,H.A; Resource – M.Y.A., Z.O; Materials –M.Y.A., K.S.O., E.K.O.; Data Collection and/or Processing M.Y.A., Z.O. S.S.; Analysis and/or Interpretation – M.Y.A, S.S., Z.O; Literature Search – M.Y.A, S.S., Z.O.; Writing – M.Y.A, S.S., K.S.O.; Critical Reviews – K.S.O., E.K.O.,H.A.

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