Journal of Medical and Scientific Research

JMSR
www.jmsronline.com

Ravindran D et al. J Med Sci Res. 2024; 12(2):101-107
http://dx.doi.org/10.17727/JMSR.2024/12-19

ORIGINAL RESEARCH OPEN ACCESS

Otological manifestations of temporal bone fractures

Darshana Ravindran[1], Shambhu Dev S[1], and Sindhu BS[1,*]

[1]Department of Otorhinolaryngology, Government T D Medical College, Alappuzha, Kerala 688005, India

Abstract

Background: Temporal bone fractures are caused by high intensity trauma and can result in various facial and cochleovestibular sequelae, which can affect the quality of life. The aim was to study about the various otological manifestations of temporal bone fractures in head trauma patients.

Methods: Descriptive study of 82 patients was conducted in the Department of Otorhinolaryngology, Government T D Medical College, Alappuzha from April 2019 to March 2021. All patients with radiological evidence of temporal bone fractures were taken for study and their symptoms and signs were compared among otic capsule sparing (OCS) and otic capsule violating (OCV) type fractures. Data was analysed statistically using SPSS version 22 and p value calculated using chi-square test.

Results: Majority of the patients were in the 20–40-year age group. Male to female ratio was 8.1:1. The most common aetiology was road traffic accidents (RTAs) n=74 (90.24%). The incidence of tinnitus (p value=0.02), vertigo (p value=0.007), facial palsy (p value=0.0004), CSFO (p value=0.0002), nystagmus (p value=0.0065) and sensorineural hearing loss (SNHL) (p value=0.00001) were found to be more in OCV type fractures and their association was found to be statistically significant. The incidence of TM perforation (p value=0.01), conductive hearing loss (CHL) (p value=0.0008) and EAC laceration (p value=0.04) was more in OCS type fractures and was statistically significant.

Conclusion: Rapid diagnosis of temporal bone fractures is crucial as it enables effective initial management aimed at avoiding the facial and cochleovestibular sequelae that can adversely affect the quality of life.

Keywords: temporal bone; fracture; facial palsy; tinnitus; otological manifestation; sensorineural hearing loss

Introduction

Temporal bone is the most complex bone in human body, which houses many vital structures like cochlea, semicircular canals, vestibule, facial nerve, carotid artery, and jugular vein. Temporal bone fractures can damage any of these vital structures. Road traffic accidents (RTAs), falls and gunshot wounds are the most common aetiological factors [1]. The number of adults getting injured in road traffic accidents have increased in the recent past. A low intensity trauma like fall from height can cause petrous temporal bone fractures and should be suspected in elderly [2]. Injuries related to temporal bone range from temporary and minor disorders to severe and permanent ones. Many of these patients sustain other life-threatening injuries which may require priority than other ones. Unrecognised otological injuries are one such group of injuries which if left untreated may lead to difficulties in rehabilitation and adversely affect the overall quality of life.

Temporal bone fractures are divided into longitudinal, transverse, and mixed type depending on the long axis of petrous temporal bone [3]. Longitudinal fracture usually begins in the squamous temporal bone, run along the roof of the EAM, tearing the tympanic membrane and cross the roof of middle ear. It may then run anterior to the labyrinth, through carotid canal and reach the foramen spinosum. One third fractures

***Corresponding author**: Dr Sindhu BS., Assistant Professor, Department of Otorhinolaryngology, Government TD Medical College, Alappuzha, Kerala 688005. Email: sindhubs16@gmail.com

Received 8 January 2024; *Revised* 24 February 2024; *Accepted* 7 March 2024; *Published* 18 March 2024

Citation: Ravindran D, Dev SS, Sindhu BS. Otological manifestations of temporal bone fractures. J Med Sci Res. 2024; 12(2):101-107. DOI: http://dx.doi.org/10.17727/JMSR.2024/12-19

will extend across the midline to be continuous with a contralateral temporal bone. Some fractures will extend anteriorly to exit the cranium through the anterior fossa floor laterally or at the midline through the cribriform plate. Transverse temporal bone fractures course from foramen magnum to the floor of the middle cranial fossa, either medial through or lateral to the otic capsule. Most commonly it passes through the otic capsule, disrupting the inner ear. The facial and vestibulocochlear nerves are at risk as fracture traverses the internal auditory meatus.

The most commonly used system classifies temporal bone fractures according to their orientation relative to the axis of petrous ridge: longitudinal or transverse [3]. Most series describe 80-90 % fractures as longitudinal and 10 – 20 % as transverse [3]. Although a convenient system, it has not been proven to correlate well with clinical signs or outcomes. An alternative system considering fractures as otic capsule sparing or violating is becoming more widely adopted [4]. Dahiya et al [4] has proved in his study that patients with otic capsule violating fractures are more likely to develop complications like facial paralysis, hearing loss. This system emphasis the structural incidence of serious sequelae like facial nerve paralysis, CSF leak, and profound hearing loss rather than fracture orientation [5]. Some caution is, however, required as others have found no statistical difference using this differentiation [5]. In one study CSF leak was only 1.1 times more common in transverse than in longitudinal fractures but was 9.8 times more common in petrous than in non-petrous fractures [3]. Facial nerve injury is also more strongly correlated with fractures through the petrous temporal than with other fracture types. Sensorineural hearing loss did correlate with the transverse fracture classification but was significantly more prevalent in petrous fractures [3].

In children there is a relative increase in transverse fractures with 59% being longitudinal and 41 % transverse [6]. This may be due to different stress and resistance lines in the paediatric skull as a result of non-fused sutures and different bone density.

Any pattern of hearing loss – immediate, delayed, transient, permanent, or progressive –may be seen in cases of temporal bone fracture [7]. A conductive hearing loss of greater than 20db HL is likely to occur in two-third of the patients tested within 72 hours of injury, with 17% persisting 6 weeks afterwards. Although a persistent hearing loss is rare in cases of mild head injury, a sensorineural hearing loss is often seen in patients who have sustained a temporal bone fracture. The affected frequencies are usually 4kHz and higher. The degree of hearing loss is proportional to the degree of head injury. Complete loss of hearing in the affected ear is reported in about 17% of the patients with a fracture.

A delayed and progressive hearing loss, without vestibular symptoms, may occur many months or years following the injury. It is thought to occur in 1 -11% of ears following temporal bone fractures and to be immunologically mediated [8]. Exposure of antigens from traumatized cochleovestibular membranes is thought to lead to immune sensitization and hence an attack on the contralateral ear. The mechanism has been hypothesized as the cause for delayed progressive hearing losses occurring in the injured ear [8].

Similar rates of posttraumatic dizziness occur following severe temporal bone trauma and after minor head injuries. It occurs in at least three-quarter s of cases. Where the petrous bone or otic capsule are spared then a mechanism of vestibular concussion is thought to occur and resolution should be relatively fast, taking a matter of days. This is unlikely due to the destructive process with fractures through the otic capsule where resolution as a result of central adaptation may take up to 12 months [7].

Facial nerve palsy complicates about 7% of temporal bone fractures, depending on the type of trauma and fracture pattern. Penetrating trauma has a higher incidence of about 52%. Facial nerve injuries occur in 10-25% of longitudinal fractures, 38 -50% of transverse and more common with otic capsule violating fractures. 66% of fractures are located at the geniculate ganglion, 20% at the 2nd genu, 8% in the tympanic segment and 6% in the mastoid portion. 6% of geniculate ganglion lesions exhibited a second site of trauma in the mastoid portion. It is important to ascertain whether the onset of facial palsy was immediate or delayed, and if partial or complete. Those cases where time of onset cannot be ascertained are best considered as immediate onset [9].

Montava et al conducted a prospective study on patients with temporal bone fractures to study about the facial and cochleovestibular sequelae and their impact on QOL [10]. It focused on the prevention of temporal bone fractures by promoting the use of helmets and improvements in helmet design. Rapid diagnosis of temporal bone fractures is crucial as it enables the effective initial management aimed at avoiding sequelae.

The aim of study was to analyse the various otological manifestations in temporal bone fractures, presenting to a tertiary care centre over a period of 2 years.

Materials and methods

The study was a descriptive and conducted in the Department of Otorhinolaryngology, Government TD Medical college, Alappuzha from April 2019 to March 2021 after getting acceptance from the institutional ethical committee. All patients coming to Otorhinolaryngology OPD, casualty and admitted in ENT wards, with radiological evidence of temporal bone fractures were taken for study. Patients who were seriously ill, not willing for taking HRCT temporal bone, with low GCS score were not taken for study, even if they had clinical features suggestive of temporal bone fracture. Informed consent was taken from all patients in their mother tongue. Participant information sheet was given to all the study subjects in their native language informing them about the procedure involved and making them aware that, they can withdraw from the study anytime they want and that this study will not affect their treatment.

Sample size (n) was calculated using the universal formula 4pq/L2, where p is the prevalence of hearing loss (56%) [10], Q is 100-P and L= 20% of P. Even though 79 was the sample size, we were able to get 82 patients for study.

Patients who had radiological evidence of temporal bone fracture, were subjected to HRCT temporal bone, for detailed study of ossicles, facial nerve, cochlea etc. Those who were not willing to take HRCT were excluded. PTA was done for all patients. Patients with vertigo was evaluated with various tests including position tests. After ruling out peripheral causes for vertigo, patient was referred to neurosurgeon/neurologist, to rule out any central cause. They were given betahistine and other labyrinthine sedatives. Those patients who presented with persistent vertigo following temporal bone fracture were advised vestibular rehabilitation exercises. Patients with facial palsy were evaluated for the site of injury and started on prednisolone at the dose of 1mg/kg/day. This was tapered over 2 weeks. They were also subjected to physiotherapy and other supportive measures. Patients with immediate onset facial palsy of HBS grade V, underwent facial nerve decompression.

Among 82 patients, 73 were males and 9 were females. Only 1 patient was there with age 12 years, who sustained temporal bone trauma, after falling from cycle. He was admitted and managed conservatively. 4 patients had CSF otorrhea, at the time of presentation. They also were admitted and put on anti-meningitis regime. Since this was a descriptive study, both old and new cases of temporal bone fractures, were included, depending on the time of presentation.

The data collected was entered in Microsoft excel and statistically analysed using SPSS software version 22 and p value was calculated using chi- square test. P value < 0.05 was taken as statistically significant.

Results

Among 82 patients, there were 73 males and 9 females. Male to female ratio was 8.1:1. Majority of the patients were in the 20-40 years age group. Mean age group was 38.4. The youngest patient was 12 years and the eldest was 68 years in our study (Table 1). We did not include patients more than 70 years of age due to other comorbidities.

Table 1: Age distribution.

Age	*n=82*	*Percentage (%)*
0-9	0	0
10-19	9	10.97
20-29	20	24.39
30-39	20	24.39
40-49	12	14.63
50-59	5	6.09
60-69	16	19.51
≥70	0	0
Total	82	100

The most common aetiology in our study was road traffic accident n=74 (90.24%). Among those patients' majority were two-wheeler accidents n=53(71.62%). They were either not using helmets or wearing it properly. Next common was pedestrian v/s car n=12(16.21%). Only one patient was there with age 12 years, who had fall from cycle, and sustained temporal bone fracture n=1(1.35%). Rest of the patients in study sustained temporal bone fracture after fall from height n=8(9.75%) (Tables 2 and 3).

Table 2: Aetiology of temporal bone fractures.

Etiology	*n=82*	*Percentage (%)*
RTA	74	90.24
Fall from height	8	9.75
Assault	0	0
Gunshot	0	0
Total	82	100

Table 3: Type of RTA.

Type of RTA	*n=74*	*Percentage (%)*
Two-wheeler accident	53	71.62
Pedestrian V/s Car	12	16.21
Cycle V/s Car	4	5.4
Fall from bus	4	5.4
Fall from cycle	1	1.35

The most common otological manifestations in our study were hearing loss n=57 (69.51%) and tinnitus n=56 (68.29%). Most of the patients had ringing type of tinnitus, some had roaring type and very few had pulsating type (Table 4).

Table 4: Otological manifestations of temporal bone fractures.

Manifestation	*N=82*	*Percentage (%)*
Bleeding from ear	29	35.36
Tinnitus	56	68.29
Vertigo	40	48.78
Facial palsy	28	34.14
CSFO	5	6.09
3rd Nerve palsy	5	6.09
Hemotympanum	44	53.65
Nystagmus	21	25.60
TM Perforation	34	41.46
Battle sign	16	19.51
EAC laceration	23	28.04
Hearing loss	57	69.51

Among the 57 patients with hearing loss, n=48(84.21%) had conductive and n=9 (15.78%) had sensorineural type of hearing loss. Profound sensorineural hearing loss was seen in n=5 patients. They were also having vertigo and CSF leak. These patients were having OCV type temporal bone fracture. Those with mild conductive hearing loss were either having a perforated tympanic membrane or hemotympanum. n=10 patients had moderate conductive hearing loss. Among them 4 had incus dislocation, 2 had fracture of ossicles and 4 had incudostapedial joint dislocation. Rest of the patients n=25 (30.48%) had normal hearing in PTA (Table 5).

Vertigo was seen in n=40 patients (46.25%). Among them n=20 patients were having BPPV, as diagnosed by position test. n=14 patients were diagnosed to have posttraumatic labyrinthine concussion, after excluding other central causes. n=6 patients were referred to neurologist, to rule out any central cause.

Table 5: Degree of hearing loss.

Degree	*N=57*	*Percentage (%)*
Mild conductive	38	66.66
Moderate conductive	10	17.54
Mild SNHL	4	7.01
Profound	5	8.77

28 patients had facial palsy (34.14%). Immediate facial palsy was seen in n= 4 (14.28%) patients. House Brackman grading score was used for facial palsy grading. All these 4 patients had grade 5 at the onset of injury. One patient had injury at the site of geniculate ganglion and other 3 had injured the tympanic segment. Rest n= 24 (85.71%). patients had grade 2 to grade 5 delayed facial palsy. They got facial palsy after 1 to 2 weeks after trauma. Radiologically facial canal was normal in these patients. They got facial palsy due to the nerve oedema [23].

Other manifestations were bleeding from the ear n=29 (35.36%), hemotympanum n= 44 (53.65%), tympanic membrane perforation n=34(41.46%), Battle sign n=16(19.51%), CSF otorrhea n=5(6.09%), EAC laceration=23(28.04%), 3rd nerve palsy n=5(6.09%). Among 40 patients with vertigo, 21 patients had nystagmus.

The incidences of each of these manifestations were compared between otic capsule sparing (OCS) and otic capsule violating (OCV) type fractures and their statistical association was calculated. p value <0.05 was taken as statistically significant. The incidence of tinnitus (p value=0.02), vertigo (p value=0.007), facial palsy (p value=0.0004), CSFO (p value=0.0002), nystagmus (p value=0.0065) and sensorineural hearing loss (SNHL) (p value=0.00001) were found to be more in OCV type fractures and their association was found to be statistically significant.

The incidence of TM perforation (p value=0.01), conductive hearing loss (CHL) (p value=0.0008) and EAC laceration (p value=0.04) was more in OCS type fractures and was statistically significant. Even though bleeding from the ear, hemotympanum, Battle sign and 3rd nerve palsy were found to be more in OCV fractures, it was not found to be statistically significant, as the p value >0.05 (Table 6).

We had included the classification of otic capsule sparing and otic capsule violating type of fractures [4]. 67 patients suffered otic capsule sparing type fracture and that was the commonest type in our study (81.7%). Rest was otic capsule violating type n=15(18.29 %) (Table 7). n=40 patients (48.78%) had right sided fractures and n=42(51.21%) had left sided fractures (Table 8).

Table 6: Otological manifestations and p value.

Manifestation	*OCS N*	*Percentage among OCS n=67*	*OCV N*	*Percentage among OCV n=15*	*P value*
Bleeding from ear	22	32.83	7	46.66	0.31118
Tinnitus	42	62.68	14	93.33	0.02113
Vertigo	28	41.79	12	80	0.007449
Facial palsy	17	25.37	11	73.33	0.000399
CSFO	1	1.49	4	26.66	0.00023
3rd Nerve palsy	4	5.97	1	6.66	0.918833
Hemotympanum	33	49.25	11	73.33	0.090928
Nystagmus	13	19.40	8	53.33	0.006499
TM Perforation	32	47.76	2	13.33	0.014426
Battle sign	11	16.41	5	33.33	0.135094
CHL	45	67.16	3	20	0.000804
SNHL	1	1.49	8	53.33	0.00001
EAC laceration	22	32.83	1	6.66	0.041416

Table 7: Type of fracture.

Type	*N= no of ears*	*Percentage (%)*
OCS	67	81.7
OCV	15	18.29
Total	82	100

Table 8: Side of temporal bone fracture.

Side	*N=no of patients*	*Percentage (%)*
Right	40	48.78
Left	42	51.21
Total	82	100

Discussion

Types of fractures has always been conflicting, in view of fracture lines in relation to the long axis of petrous bone. In the study by Little and Kesar [11], the incidence of longitudinal fractures was 50%. The incidence of longitudinal fractures in studies by Rafferty [12] was 29% and Bechara [13] was 4.5% respectively. It would be scientific to describe the fracture lines to be either otic capsule sparing or violating ones [4]. Otic capsule was more often spared than violated in most of the fractures and in most of the studies. In our study also, we had more OCS fractures (81.7%) than OCV fractures (18.29%).

In OCS fractures, the incidence of conductive hearing loss and ear bleeding is more than in OCV fractures. Conductive hearing loss may be due to hemotympanum, perforated ear drum, or a disrupted ossicular chain [14, 15]. In our study 29 patients (35.36%) had bleeding from the ear, 44 patients (54.87%) had hemotympanum, 34 patients (19.5%) had tympanic membrane perforation, on examination. Among patients with hearing loss n=57, CHL was seen in 48 patients (84.21%). Among them 10 patients had moderate conductive hearing loss. Hemotympanum resolves within a month. Those with tympanic membrane perforation can observe a wait and watch policy for 3months. Even after 3 months, if the perforation is not healing, they need myringoplasty. Those with ossicular chain disruption need ossiculoplasty. Those with tympanic membrane perforation can later have a discharging ear. Among the 34 patients with tympanic membrane perforation in our study, 4 patients (12%) gave history of mucopurulent discharge from the affected ear.

Sensorineural hearing loss was seen in 9 patients in our study. Among them 5 had profound sensorineural hearing loss and other 4 had mild sensorineural hearing loss. One of these patients suffered OCS fracture and rest of the 8 patients suffered OCV type fractures. Other 3 patients who suffered OCV type fractures, had mild conductive hearing loss associated with other manifestations. The incidence of SNHL in OCS fractures was 1.49% and OCV was 53.3% in our study. In study by Rafferty et al [5], SNHL was reported in 7% of cases with OCS type fractures and 100% in OCV type fractures. In Little and Kesser studies [11], SNHL was reported in 4% cases with OCS type and 100% in OCV type fractures. The mechanisms involved in SNHL are disruption of membranous labyrinth, avulsion or trauma to cochlear nerve, interruption of cochlear blood supply, haemorrhage into cochlea, perilymph fistula and endolymphatic hydrops due to obstruction of endolymphatic duct by fracture fragment [16].

Among 5 patients with CSFO, 4 patients (26.66%) had OCV type fractures and 1patient had OCS type fracture (1.49%). While Gupta [17] and Brodie [18] reported 14% and 15% respectively in their studies. These leaks stopped spontaneously in most of the patients in 2 weeks.

Facial palsy was seen in 34.14 % cases in our study. It was less than 10% in most of the studies. This was mostly seen in OCV type fractures. In studies by Gupta et al [17] it was 9%, Schuble [19] it was 1.6%, and in Brodie [18] it was 7%.

The most common otological manifestation in our study were hearing loss (69.51%) and tinnitus (68.29%). Tinnitus and SNHL were more common in OCV type fractures, while CHL was more common in OCS type fractures, and were found to be statistically significant. Even though patient had other manifestations, tinnitus was the most annoying type of symptom for patients. It was the last symptom to resolve. Among the 56 patients in our study, who had tinnitus, 3 required the use of tinnitus maskers for their relief. Others were given labyrinthine sedatives and tranquillisers. Many of them had disturbed sleep because of the tinnitus. Those patients with OCS type fractures, where ossicular chain and labyrinth was intact, MRI brain was also taken to rule out any other neurogenic /vascular cause. But it was normal.

The result of our study was compared with other similar studies in literature (Table 9). Most of them got bleeding from the ear as their most common otological manifestation [17, 21-24]. Study done by Prasad et al on 57 patients [20] got facial palsy as their most common otological manifestation. Conductive hearing loss was got in study by Yalcenir et al [25].

Table 9: Comparative incidence of various otological manifestations in various studies.

Reference	*No. of cases*	*Most common otological manifestation*	*Percentage (%)*
Prasad et al [20]	57	Facial paralysis	68
Chang et al [21]	35	Bleeding from ear	82.8
Venugopalan et al [22]	100	Bleeding from ear Hearing loss	59 59
Gupta et al [17]	86	Bleeding from the ear	70
Basavaraju et al [23]	154	Bleeding from ear	68.8
Ricciardiello et al [24]	141	Otorrhagia	89.84
Yalciner et al [25]	77	Conductive hearing loss	65.8
Our study	82	Hearing loss Tinnitus	69.51 68.29

By this study we have tried to create awareness among youngsters about use of helmets while driving two wheelers. As prevention is better than cure, by taking such a simple step, we will be able to avoid serious faciocochleovestibular sequelae, that can affect our quality of life [10].

Limitations of the study: As our study was conducted during the covid times and the incidence of RTAs were less due to lockdown times, sample size was small. Even though certain patients with head injury had temporal bone fractures, they were not included due to low GCS scores. Patients with temporal bone fractures admitted in other surgery and neurosurgery wards were not taken for study due to covid restrictions.

Take home message: The number of adults getting injured in road traffic accidents have increased in the recent past. Most of these RTAs are due to driving of two-wheeler vehicles without using helmets. Unrecognised otological injuries are one such group of injuries which if left untreated may lead to difficulties in rehabilitation and adversely affect the overall quality of life. Temporal bone fractures can be prevented by using helmets or improving the helmet design in 2 wheelers. Rapid diagnosis of temporal bone fractures is crucial as it enables effective initial management aimed at avoiding the facial and cochleovestibular sequelae that can adversely affect the quality of life.

Conclusion

The most common cause for temporal bone fractures are road traffic accidents. Most of these RTAs are due to driving of two-wheeler vehicles without using helmets. Detailed study of these fractures should be done using HRCT of temporal bones. Classifying these fractures based on the involvement of otic capsule as, OCS and OCV fractures demonstrated a far better correlation with respect to hearing loss. OCS type fractures are more common than OCV type fractures. Hearing loss and tinnitus were the most common complications associated with temporal bone fracture in our study.

Conflicts of interest

Authors declare no conflicts of interest.

References

[1] Abhishek M, Kaleeswaran R, Srinivasan K. Assessment of hearing loss in temporal bone fractures. Indian J Otol. 2021; 27:158–162.

[2] Green L, Wang J, Li C, Tully D, Woliansky J, et al. Management of petrous temporal bone fractures: a 5-year experience from an Australian major trauma centre. Aust J Otolaryngol. 2022; 5:27.

[3] Ishman SL, Friedland DR. Temporal bone fractures: traditional classification and clinical relevance. Laryngoscope. 2004; 114:1734–1741.

[4] Dahiya R, Keller JD, Litofsky NS, Bankey PE, Bonnasser LJ, et al. Temporal bone fractures: Otic capsule sparing versus otic capsule violating, clinical and radiological considerations. J Trauma. 1997; 47:1079–1083.

[5] Rafferty MA, Walsh RMC, Walsh MA. A comparison of temporal bone fracture classification systems. Clin Otolaryngol. 2006; 31:287–291.

[6] Kang HM, Kim MG, Hong SM. Comparison of temporal bone fractures in children and adults. Acta Otolaryngol. 2013; 133:469–474.

[7] Johnson F, Semaan MT, Megerian CA. Temporal bone fractures: evaluation and management in the modern era. Otolaryngol Clin North Am. 2008; 41:597–618.

[8] Cate WJFT, Bachelor E. Autoimmune mediated sympathetic hearing loss; a case report. Otol Neurotol. 2005; 26:161–165.

[9] Yetisar S, Hidir Y, Gonul E. Facial nerve problems and hearing loss in patients with temporal bone fractures: demographic data. J Trauma. 2008; 65:1314–1320.

[10] Motanova M, Mancini J, Masson C, Collin M. Temporal bone fractures: Sequelae ad their impact on Quality of life. Am J Otolaryngol. 2015; 36:364–370.

[11] Little SC, Kesar BW. Radiographic classification of temporal bone fractures: clinical probability using a new system. Arch Otolaryngol Head Neck Surg. 2006; 132:1300–1304.

[12] Rafferty MA, Conn WRM, Walsh MA. A comparison of temporal bone classification system. Clin Otolaryngol. 2006; 31:287–291.

[13] Bechara YG, Joel WY. Temporal bone fracture: longitudinal or oblique? Laryngoscope. 1992; 102:129–134.

[14] Kochhar LK, Deka RC, Kacker SK, Raman EV. Hearing loss after head injury. Ear Nose Throat J. 1990; 69:537–542.

[15] Deshmukh KA, Fatima U, Siddiqui A, Tegnoor MS. Evaluation and Outcomes of Hearing Loss in Temporal Bone Fractures: A Prospective Study. Cureus. 15:e46331.

[16] Bergemalm PO. Progressive hearing loss after closed head injury: a predictable outcome? Acta Otolarngol. 2003; 123:836–845.

[17] Gupta N, Varshney S, Bist SS, Bhatia R. A study of temporal bone fractures. Indian J Otolaryngol Head Neck Surg. 2008; 60:223–226.

[18] Brodie HA, Thompson TC. Management of complications from 820 temporal bone fractures. Am J Otol. 1997; 18:188–197.

[19] Shuble SD, Klein TR. Robitsek RJ. Temporal bone fracture: evaluation in the era of modern CT. Imaging. 2016; 47:1893–1897.

[20] Prasad BK, Basu A, Sahu PK, Rai AK. A Study of otological manifestations of temporal bone fractures. Indian J Otolaryngol Head Neck Surg. 2022; 74:351–359.

[21] Chang WP, Kim JG, Kim JH, Bang SH. An Otologic Study of the traumatic temporal bone fractures. Korean J Otorhinolaryngol-Head Neck Surg. 1990; 33:1115–1121.

[22] Venugopalan S, Mehta MR. Temporal bone trauma management: A study of 100 cases. Indian J Otolaryngol Head Neck Surg. 2022; 74:299–306.

[23] Basavaraju U, Jayaramaiah SK, Turamari RU, Prakash V, Mankan S. Temporal bone fractures and its classification: Retrospective Study of Incidence, Causes, Clinical Features, Complications and Outcome. Int J Anatom, Radiol Sur. 2017; 6:RO57–RO61.

[24] Ricciardiello F, Mazzone S, Longo G, Russo G, Piccirillo E. Our experience on temporal bone fractures: retrospective analysis of 141 cases. J Clin Med. 2021; 10:201.

[25] Yalciner G, Kutluhan A, Bozdemir K, Çetin H, Tarlak B, et al. Temporal bone fractures: evaluation of 77 patients and a management algorithm. Turk J Trauma Emerg Sur. 2012; 18:424–428.