External auditory canal injuries in maxillofacial trauma – Proposal of a symptom-based treatment algorithm with a report of twelve cases

ABSTRACT

Purpose: Injury to the external auditory canal (EAC) may occur following facial trauma. They manifest as otalgia, ear bleeding, otorrhea, facial palsy, or altered hearing. But literature regarding its management is sparse. The study aimed to identify the incidence and types of EAC injury in facial trauma, grade their severity, and propose a symptom-based treatment algorithm.

Patients and Methods: This was a prospective case series involving patients with signs/symptoms of EAC injury following maxillofacial trauma. The EAC was evaluated by clinical examination, imaging, endoscopy, and audiometry. Clinical findings were graded into mild, moderate, and severe. Treatment was matched to clinical findings according to the proposed algorithm. The outcomes of the study were incidence and types of EAC injury in facial trauma and resolution of presenting signs/symptoms. Data were analyzed for descriptive statistics using SPSS software (v26; IBM, Armonk, NY).

Results: A total of 88 patients reported with maxillofacial trauma during a 6-month period. Signs/symptoms of EAC injury were observed in 41 patients, of which 12 (11 males and 1 female) were confirmed with a diagnosis of EAC injuries. Eight patients demonstrated only cartilaginous injuries while three had bony injuries. Treatment was successful in 11 out of 12 patients, with a best point estimate of 0.86 (Z score-1.959, 95% CI).

Conclusion: Clinical findings of EAC injury mandate thorough investigation to ascertain the site and severity of the injury. Symptom-based treatment of EAC injuries produces an effective resolution of signs/symptoms and improved treatment outcomes.

Keywords: Ear, external auditory canal, fracture, maxillofacial, trauma

INTRODUCTION

Injury to the external auditory canal (EAC) may occur following trauma to the maxillofacial skeleton. These injuries frequently manifest as otalgia, ear bleeding, otorrhea, hemotympanum, facial nerve paresis, or hearing loss.[1,2] Most of these symptoms overlap with the clinical features of injury to other facial/cranial bones. Hence, these injuries are frequently overlooked or inadequately assessed, resulting in clinical complications such as EAC stenosis,[3,4] altered hearing,[3] infection,[5] ankylosis,[6] and cholesteatoma.[7] The complications partly result from poor awareness among maxillofacial surgeons regarding the pathophysiology, clinical features, and management of EAC injury.

The EAC may be injured by two mechanisms: (1) direct trauma to the EAC or (2) indirect trauma due to posterior dislocation of condyle impacting the anterior wall of EAC, which also constitutes the posterior wall of glenoid fossa[5,8] [Figures 1 and 2]. Injuries to the EAC may involve the

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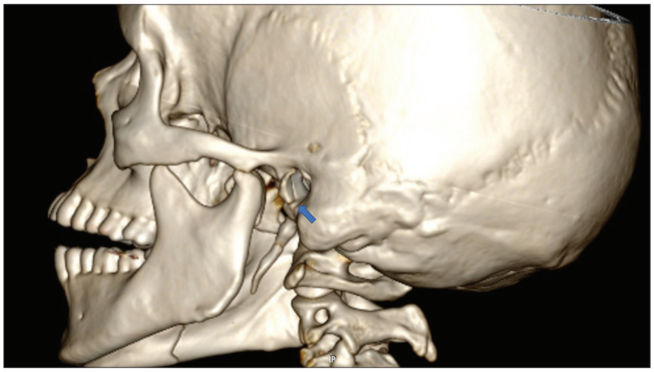

Figure 1: CT demonstrating EAC fracture

cartilaginous, osseous, or osseocartilaginous part of the EAC. The incidence of EAC injury reported in the literature ranges from 0.7%[9] to 32%.[10] Despite the documented frequency in medical literature, fractures of the EAC are often undetected in the maxillofacial scenario and reports of EAC fractures are minimal in maxillofacial literature.

Currently, there are no established protocols for the diagnosis and management of EAC injuries in maxillofacial literature. The purpose of the study was therefore to evaluate the incidence and types of EAC injuries in facial trauma and determine outcomes following a symptom-based treatment algorithm.

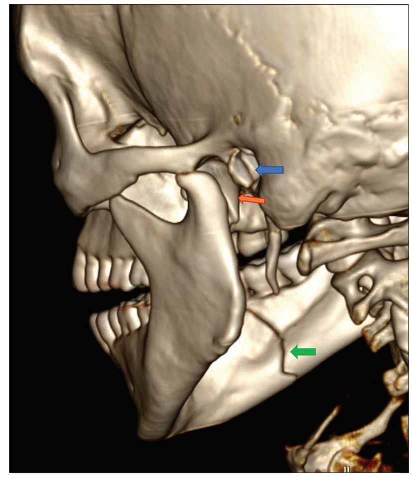

Figure 2: CT image of the patient in Figure 1, demonstrating EAC fracture (blue arrow) and associated fractures, condyle head fracture (red fracture), and body fracture (green arrow)

Table 1: Clinical signs/symptoms for patient inclusion

Signs and symptoms
Otalgia
Peri aural redness/abrasion
Peri aural swelling
Bleeding or discharge per aural
Ear block
Altered hearing
Limitation/pain on mouth opening/chewing

PATIENTS AND METHODS

Study design

The authors implemented a prospective case series to evaluate EAC injuries associated with maxillofacial trauma. Ethical Clearance was obtained from SRM Institutional Ethical Committee with Ref no SRMU/M&HS/SRMDC/2019/S/003 dated 10.01.2019 and the study was performed in accordance with the CARE guidelines.[11] The study followed the Helsinki declaration for medical research involving humans.

Patient selection

Patients reporting to the department of oral and maxillofacial surgery with signs/symptoms of EAC injury [Table 1] following maxillofacial trauma during a 6-month period were recruited into the study. Patients were explained about the study and consent was obtained to participate in the study. Patients aged 20–40 years and who consented to be part of the study were included. Patients with associated traumatic brain injury, previous history of TMJ dysfunction, or pre-traumatic ear disorders and their treatment were excluded from the study.

Methodology

Descriptive data such as the patient's age, sex, type of injury (road traffic accident (RTA), sports injury/assault), and diagnosis were collected. This was followed by patient evaluation, treatment, and follow-up as detailed below.

Patient evaluation

The patient sample was evaluated utilizing four different modalities. Evaluations were done by (i) clinical examination (ii) computed tomography (CT) imaging (iii) endoscopy, and (iv) audiometry. Disruption in the cartilaginous or osseous component of the EAC was considered as an EAC injury.

Clinical assessment was done by Investigator 1 (Maxillofacial Surgeon). The symptoms mentioned by patients and signs elicited by the investigator were tabulated. CT (Siemens Somatom, Germany, 0.6 mm slices, 260 mA) images were evaluated by Investigator 2 (Radiologist) for the presence of EAC injury and its location [Table 2]. The endoscopic examination (Karl Storz, Germany, 0°, 1.9-mm in diameter with 4K resolution) of EAC was performed by Investigator 3 (ENT surgeon) for the presence of lacerations, infection [Figure 3], bleeding [Figure 4], and polyps [Figure 5]. Pure tone audiometry (PTA) (Graphics Digi 15 audiometer, Graphic hearing aids, Chennai, India) was conducted by Investigator 4 (Audiologist) to identify conductive or sensorineural deafness. Patients were then categorized into mild, moderate, and severe grades, based on the severity of symptoms and functional limitations such as reduced mouth opening and hearing impairment [Table 3].

Table 2: Types of EAC injuries

Type	Definition
Type I	Involvement of cartilaginous part of EAC
Type II	Involvement of osseous (tympanic) part of EAC II A – Un-displaced II B – Displaced
Type III	Involvement of osseous part extending into the skull base

Table 3: Severity of signs/symptoms and grading

Grade	Symptoms
Mild (no limitation of function)	Mild otalgia Redness Swelling Abrasion
Moderate (limitation of function present)	Symptoms of mild category + Moderate to severe otalgia EAC bleed Blocked ear Limitation of mandibular movements
Severe (limitation of function present with/without secondary changes)	Symptoms of moderate category + Secondary changes (discharge/polyp, sec infection) Hearing loss

Institution of treatment

The facial fractures concomitant with EAC injuries were treated by either open reduction internal fixation (ORIF) or conservative methods, as indicated. This was followed by treatment of the EAC injury in accordance with the authors' institutional protocol, where treatment was matched to the clinical findings [Figure 6]. Patients with spontaneous otalgia were prescribed non-steroidal anti-inflammatory drugs (NSAIDs) (aceclofenac 100 mg and paracetamol 325 mg) for 5 days. Otalgia on mouth opening was managed with NSAIDs for 5 days and a soft diet. Restriction of mouth opening was instituted using intermaxillary fixation (IMF) or a cervical collar for 10 days. Mild bleeding was treated with an antibacterial pack (framycetin 1 mg impregnated tulle gras) for a week. A steroid pack (1% hydrocortisone cream) was used subsequently for a week. Patients with altered hearing were prescribed NSAIDs for 5 days. When symptoms did not resolve, PTA was recommended. Positive PTA required further management by an ENT surgeon. Laceration in the EAC was assessed by endoscopy. Laceration without tissue loss was treated with an antibacterial gauze pack for a week or suturing when necessary. Tissue loss in the EAC mandated reconstruction with cartilage graft or gel patch. The presence of secondary changes such as discharge or infection was managed with empirical antifungal therapy (fluconazole 150 mg), twice a week, and topical clotrimazole 1%, twice a day. Patients with unresolved symptoms were subjected to endoscopic lavage with warm normal saline and swab culture followed by specific antimicrobial therapy.

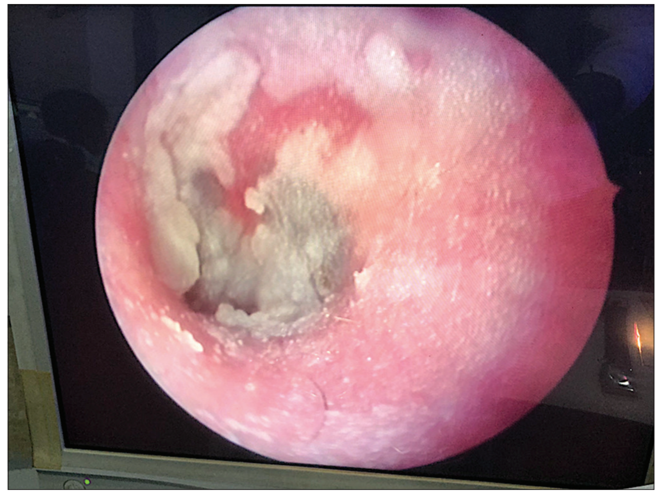

Figure 3: Otomycosis involving EAC

Figure 4: Ear bleeding within EAC

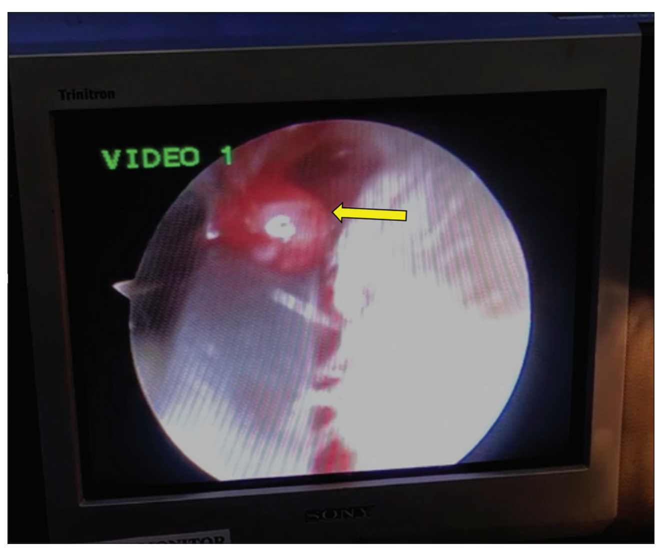

Figure 5: Polyp involving EAC

Follow-up and outcome assessment

A review of symptoms was done on post-operative days 1, 3, 7, 14, and 28 [Table 4]. Treatment outcome was documented for

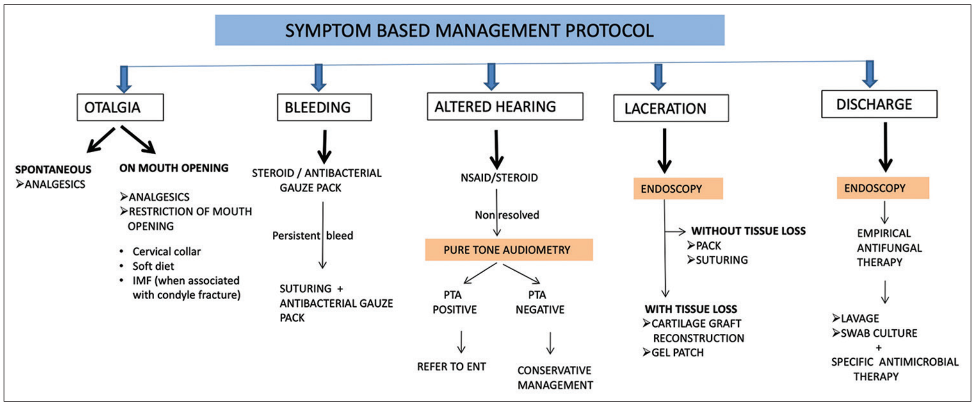

Figure 6: Treatment algorithm

resolution of signs/symptoms and scored using a modification of the scoring system described by Panneerselvam *et al*.[12] [Table 3], with 0 indicating resolution of symptoms, 1 – reduction of symptoms, and 2 – non-resolving symptoms. The success of the treatment guideline was determined using the outcomes of all 12 patients.

Variables and outcomes

The study variables included age, gender, types of EAC injury, severity, and resolution of symptoms. The outcomes studied were the incidence of EAC injury and treatment outcomes.

Statistical analysis

Data were statistically analyzed using SPSS Statistics for Windows V.22 (IBM. Version 26.0. Armonk, NY: IBM; 2013). Descriptive statistics for gender, age, symptoms, and type of injury included frequency and mean. The success of the treatment was statistically analyzed using the best point estimate.

RESULTS

A total of 88 patients were treated for maxillofacial trauma in our institution during the study period, of which 41 patients (34 males and 7 females) demonstrated signs/symptoms of EAC injury. A definitive diagnosis of EAC injury was confirmed in 12 patients, which revealed an incidence of 13.64% (12/88 patients) in this series. The gender-wise distribution was 11 males (91.67%) and 1 female patient (8.33%).

Eight patients demonstrated isolated cartilaginous injuries of the EAC (Type 1), while three patients presented with bony EAC injuries (Types 2 and 3). Otalgia was recorded in all the patients. The functional disability most frequently noted was restricted mouth opening (8 patients), followed by altered hearing due to ear block/loss of hearing [Table 5]. A total of 15 facial fractures were recorded in the 12 patients, with fracture of the condyle (8/15) being the most common facial fracture concomitant with EAC injury (neck-5 and 3-subcondyle).

Complete resolution of signs/symptoms was recorded in 11 (91.7%) out of the 12 patients with EAC injuries [Table 5], with one patient having persistent ear discharge beyond the follow-up period. The success of the treatment was statistically analyzed using the best point estimate and was found to be 0.86 by Laplace estimation (Z score -1.959, 95% CI). This demonstrates that the probability of success when using our algorithm is 86% with an accuracy of 95%.

DISCUSSION

EAC injuries may be due to direct or indirect maxillofacial trauma. These are often neglected due to a lack of awareness among maxillofacial surgeons. This study evaluated a series of patients with facial trauma concomitant with EAC injury. The outcomes evaluated were the incidence and types of EAC injuries and the success of treatment. From a pool of 88 patients treated for facial trauma, we observed an incidence of 13.6% for EAC injuries. Treatment of these injuries using a symptom-based guideline demonstrated successful outcomes. This study has also established that a thorough evaluation of clinical findings is warranted for appropriate management.

Numerous lacunae exist in contemporary literature regarding the management of EAC injuries; (i) neglect of cartilaginous injuries and (ii) current literature are predominantly case reports with no systematic investigation and management guidelines. Considering the above limitations, this study has been performed using four modalities, namely, clinical examination, CT imaging, endoscopy, and audiometry with an institution of a symptom-based treatment guideline.

Rationale behind guidelines for evaluation and treatment

Precise localization and assessment of injury are important in choosing the most effective treatment. CT or CBCT (cone-beam

Table 4: Review with the scoring of treatment outcome

Patients with EAC Fracture	Concomitant Facial Injuries	Relief of symptoms					Score	Treatment Outcome
		POD* 1	POD* 3	Week 1	Week 2	Week 4		
1.	Rt C + Lt A#	2	1	1	1	0	5	Resolved
2.	B/L C + Lt A#	2	2	1	1	0	6	Resolved
3.	Lt C + Rt PS#	2	2	2	1	0	7	Resolved
4.	Laceration	2	1	1	0	0	4	Resolved
5.	Panfacial#	2	2	1	1	0	6	Resolved
6.	Laceration	2	1	1	0	0	4	Resolved
7.	Lt C #	2	2	2	1	0	7	Resolved
8.	Lt C#	2	1	1	1	0	5	Resolved
9.	Lt C + S#	2	2	2	2	2	10	Not resolved
10.	Abrasions	2	1	1	1	0	5	Resolved
11.	Rt C + S + Rt ZMC#	2	2	1	1	0	6	Resolved
12.	Abrasions	2	2	1	1	0	6	Resolved
Mean rank		4.5	3.75	3.08	2.42	1.25		
P				<0.001				

*POD – Post-operative day, Rt – Right side, Lt – Left side, #Fracture, C – Condyle, A – Angle, PS – Parasymphysis, S – Symphysis, ZMC – Zygomatico maxillary complex

Table 5: Summary of all study variables

Variables	Descriptive statistics
Total number of patients with maxillofacial trauma	88
Patients with signs/symptoms of EAC injury	41 (46.59%)
Patients with a diagnosis of EAC injury	12 (13.64%)
Gender (*n*=12)	
Male	11 (91.66%)
Female	1 (8.33%)
Age in years (*n*=12)	
Range	21 to 40
Mean (Std. dev)	30.67 (6.54)
Distribution of concomitant fractures (*n*=15)	
Mandible	5 (33.3%)
Condyle	8 (53.3%)
ZMC	1 (6.7%)
Pan-facial	1 (6.7)
Site of EAC injury (*n*=12)	
Type 1	8 (66.67%)
Type 2A	2 (16.67%)
Type 2B	1 (8.33%)
Type 3	1 (8.33%)
Symptoms (*n*=51)	
Otalgia	12 (24.5%)
Redness	6 (11.8%)
Swelling	4 (7.8%)
Limitation in mandibular movements	8 (15.7%)
Bleeding from EAC	5 (9.8%)
Secondary changes	9 (17.6%)
Ear block	6 (11.8%)
Hearing loss	1 (2%)
Grades (*n*=12)	
Mild	4 (33.3%)
Moderate	0 (0%)
Severe	8 (66.7%)
Treatment outcomes (*n*=12)	
Unresolved	1 (8.3%)
Resolved	11 (91.7%)

computed tomography systems)[13] imaging reveals the osseous injury accurately but provides less information regarding the cartilaginous component. This greatly under-represents the injuries to the cartilaginous part, which are more common and clinically significant.[14] This enhances the value of alternative diagnostic modalities such as endoscopy and PTA, which need to be exploited for better clinical outcomes.[15] Endoscopy aids in the accurate diagnosis of lacerations, hematomas, microbial colonization, or polyps involving the EAC, while PTA is mandatory in patients with altered hearing, to quantify the hearing loss and identify the cause (conductive or sensorineural).[16]

Guidelines for managing EAC injuries are negligible in the literature. Burchhardt *et al*.[8] discussed the clinical findings associated with EAC injuries, which were consistent with our observations. However, our study demonstrated two additional findings, namely, otalgia and infection. Further, the evaluation of patients in their series was based on CT imaging alone, with a lack of differentiation between osseous and cartilaginous injuries. Another retrospective review[17] studied EAC injury using CT data, clinical records, PTA, and otoscopy, in confirmed cases of EAC fractures. This was in contrast to our study wherein endoscopy was used for all patients to identify non-osseous EAC injuries and associated secondary changes, to facilitate early treatment. Further, our study was prospective in nature, which evaluated treatment outcomes following a symptom-based treatment guideline. Otalgia which was mild/moderate and did not increase on opening the mouth indicated localized inflammatory pain and responded well to NSAIDs.[18] Commonly used NSAIDs mentioned in literature are diclofenac, ibuprofen, and acetaminophen. Otalgia becoming severe with mouth opening was due to the posterior movement of the condyle impinging on the lacerated or fractured canal. Hence, restriction of mouth opening was advised, to allow a short period of healing. This was usually achieved with a soft diet, the use of a cervical collar, or IMF with elastics.

Ear bleeding in the absence of a skull base injury reflected a lacerated cartilaginous canal and responded well to framycetin antibiotic packs. Other effective topical antimicrobial agents include flavine,[19] chloramphenicol, ciprofloxacin, neomycin, polymyxin B, ofloxacin, and Xeroform (gauze with petrolatum and 3% bismuth tribromophenate) stenting.[8] The advantages of using Xeroform include its pliable, non-adherent characteristics and moisturizing ability, which is conducive to healing. Epinephrine-soaked cottonoids and diathermy have also been effectively used for EAC bleeding.[20] Further bleeding may be prevented by IMF and suturing with absorbable sutures.[21] Untreated lacerations of the EAC are at a higher risk for stenosis in the late post-operative phase, due to fibrosis. Hence a steroid-soaked pack was recommended as a topical measure for our patients.[22] Antibiotics play a minor but important role in preventing stenosis, by combating granulation secondary to infection.[23]

Microbial colonization and hematoma required debridement by lavage, while polyps required excision. Endoscopy-assisted lavage or surgical excision ensured excellent post-operative outcomes in our patients. The most common pathogens found in EAC are fungi and hence antifungal drops or wicks are the primary antimicrobial agents of choice,[24,25] which may be augmented with systemic antifungal therapy. "Altered hearing" occurred in two forms in our patient sample; ear block and loss of hearing. Many of our patients who complained of post-traumatic ear block, responded well to NSAIDs. This symptom could be attributed to post-traumatic edema in the peri aural tissues. Glucocorticoids such as dexamethasone and fluocinolone acetonide also play an effective role in achieving the same results. Conductive hearing loss due to displaced EAC fracture and fibrous polyp has been effectively resolved by fracture reduction[1] and resection of the polyp. Loss of hearing requires prompt investigation with audiometry to assess the severity. Patients demonstrating positive PTA findings require evaluation by an otolaryngologist, to assess the need for cochlear implants.[26]

Limitations of the study and future scope

A randomized controlled trial with a significant sample size comparing our recommendations against existing treatment modalities would further validate our findings.

CONCLUSION

EAC injuries resulting from maxillofacial trauma require thorough evaluation. The use of CT imaging, endoscopy, and audiometry aid in localizing the injury and grading its severity. A symptom-based management ensures the successful resolution of signs and symptoms in patients with EAC injuries.

Informed consent has been obtained from all patients for use of clinical and photographic material.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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