Role of the Maxillofacial Surgeon in Identifying the Correlation Between Facial Bone Fractures and Traumatic Brain Injury - A Prospective Study

Romir Navaneetham, Suresh Menon, M. Ehtaih Sham, Veerendra Kumar

Department of Oral Maxillofacial Surgery, Vydehi Institute of Dental Sciences, Bengaluru, Karnataka, India

Abstract

Introduction: Maxillofacial trauma accounts for a high percentage of patients reporting to the emergency medicine department and being admitted in the hospital. The purpose of this study was to form a direct association between maxillofacial fractures and traumatic brain injury (TBI). **Methods:** Ninety patients with maxillofacial fractures that reported to/were referred to the Department of Oral and Maxillofacial Surgery were observed for features indicative of TBI based on clinical presentation and radiological interpretations. Parameters such as loss of consciousness, vomiting, dizziness, headache, seizures and the requirement for intubation, cerebrospinal fluid rhinorrhoea and otorrhoea were also assessed. Appropriate radiographs for the diagnosis of the fracture were taken followed by a computed tomography (CT) scan when indicated in accordance to the Canadian CT Head Rule. These scans were then assessed for contusion, extradural haemorrhage, subdural haemorrhage, subarachnoid haemorrhage, pneumocephalus and cranial bone fracture. **Results:** A total of 90 patients were evaluated, of which 91.1% were males and 8.9% were females. Association between the occurrence of head injury and different maxillofacial bone fractures using the Chi-square test showed a statistical significance of <0.001 in patients with naso-orbito-ethmoid as well as frontal bone fractures. There was a clear association between fractures present in the upper as well as the middle third of the face and traumatic head injury ($P \leq 0.001$). **Discussion:** Patients with the frontal bone and zygomatic bone fractures have a high prevalence of TBI. Patients with the upper and middle third of the face injury are more prone to traumatic head injury and importance should be given to patients with the same and prevent poor prognosis.

Keywords: Frontal bone fractures, maxillofacial fractures, traumatic brain injury

Introduction

The proximity of maxillofacial bones to the cranium would indicate that there are chances of traumatic brain injuries (TBIs) occurring simultaneously with facial fractures.[1] A common thought is that the face protects the brain from external injury, but recent findings have shown that the proximity of the facial skeleton to the cranium, may sometimes determine the pattern or even the presence/absence of brain injury secondary to facial fractures.[2]

TBI is defined as non-degenerative, non-congenital insult to the brain from an external mechanical force, possibly leading to permanent or temporary impairment of cognitive, physical and psychosocial functions, with an associated diminished or altered state of consciousness.[3] A common scale used in grading TBI is with the use of the Glasgow Coma Scale. A score between 15 and 13 indicated mild TBI, whereas a score between 12–9 and 8–3 indicate moderate and severe TBI, respectively. It is currently the leading cause of death and disability in adolescents and young adults.[4]

Maxillofacial trauma accounts for a high percentage of patients reporting to the emergency medicine department and being admitted in the hospital. Blunt or penetrating trauma leads to

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Address for correspondence: Dr. Romir Navaneetham, #11, Cornwell Road, Langford Gardens, Bengaluru - 560 066, Karnataka, India. E-mail: romir.is.navaneetham@gmail.com

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such injury. These injuries may be caused by many different mechanisms such as road traffic collisions, assaults and incidents in the workplace, as well as sports-related injuries. Simultaneously, such mechanisms can also give rise to TBIs, with a wide range of clinical presentations from mild to severe, varying radiological appearances and different courses of management, both surgical and non-operative. Given the shared mechanisms that can result in a blow to the head, it is, therefore, clear that patients referred to maxillofacial services for maxillofacial fractures are at risk of concurrent TBI. As opposed to injuries in other parts of the body, injury to the brain is hard to diagnose immediately as they present with mild symptoms initially. This is because the brain is enveloped in a rigid bony structure. The severity of brain injury, therefore, depends on the structural damage of the brain tissue and the extent of the haemorrhage. Early recognition of symptoms of intracranial damage is hence imperative.[5]

Diagnosis of TBI relies heavily on the history given by the patient or bystanders, and often signs may be no longer evident by the time the patient presents to medical professionals. A thorough history of loss of consciousness with a history of vomiting or seizures at the time of the accident may be imperative for a prompt diagnosis. Due to the heterogeneity, it can be difficult for clinicians to diagnose more subtle injuries to the brain, particularly in cases where there is no radiological evidence of intracranial haemorrhage.[6] Hence, diagnostic evaluation and knowledge of presenting signs and symptoms are important in the early stage to clarify emergent injuries and to pre-operatively assess and plan for functional rehabilitation of the patient.[3]

This study, therefore, evaluated the individuals with traumatic injuries to the maxillofacial skeleton from different mechanisms to assess the incidence of head injury associated with it, the type of head injury and the role of the maxillofacial surgeon in identifying this comorbid condition.

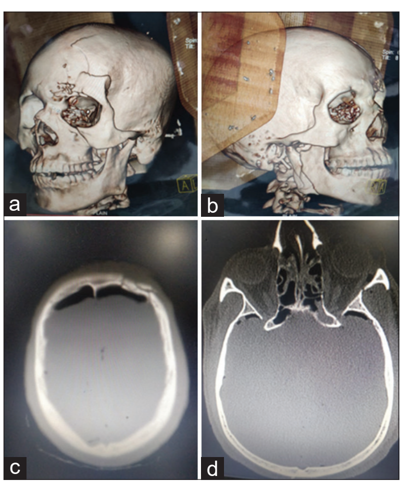

Figure 1: Case of road traffic accident. (a and b) 3D reconstruction of CT showing comminuted fracture in relation to right ramus of mandible left zygomatic complex and frontal bone fracture. (c and d) Axial sections of CT showing pneumocephalus seen in relation to frontal region and anterior mid-brain region

Materials and Methods

This prospective study was conducted over a 2-year period. A total of 90 patients with maxillofacial fractures that reported to/were referred to the Department of Oral and Maxillofacial Surgery were observed for features indicative of TBI based on clinical presentation and radiological interpretations. This association between the presence of clinical findings and head injury based on different regions of maxillofacial injuries was analysed using the Chi-square test.

Inclusion criteria

Patients that are diagnosed with maxillofacial fractures.

Exclusion criteria

- Patients that did not have any maxillofacial fractures
- Patients who were not evaluated for TBI.

Methodology

On reporting to the Department of Emergency Medicine, patients were first stabilised, following which they were clinically analysed and radiographically diagnosed by Departments of Neurosurgery, Oral and Maxillofacial Surgery and General Surgery.

Patients were assessed and diagnosed for TBI with the help of the Glasgow Coma Scale as well as the presentation of any clinical features of TBI on their arrival to the emergency department. Patients were categorised into mild, moderate and severe TBI based on Glasgow Coma Scale. Confounders which could possibly influence the inferences drawn from this study are the influence of alcohol or narcotics on the patient and the inability for the patient to understand or express themselves which would affect the ability to assess the Glasgow Coma Scale (GCS) of the patient.

Parameters such as loss of consciousness, vomiting, dizziness, headache, seizures, and the requirement for intubation, cerebrospinal fluid rhinorrhoea and otorrhoea were also assessed. Appropriate radiographs for the diagnosis of the

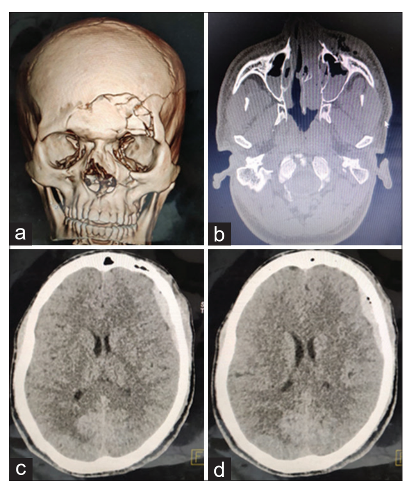

Figure 2: Case of self-fall. (a and b) 3D Reconstruction and axial section of CT, respectively, showing frontal bone, nasal bone and left infraorbital rim fracture. (c and d) Axial sections of CT showing EDH (Epidural Hematoma) and pneumocephalus noted in relation to left temporal region

fracture were taken followed by a computed tomography (CT) scan when indicated in accordance to the Canadian CT Head Rule and New Orleans Criteria. These scans were then assessed for contusion, extradural haemorrhage, subdural haemorrhage, subarachnoid haemorrhage, pneumocephalus, cranial bone fracture and penetrating injuries.

The primary variables adopted were loss of consciousness, vomiting, dizziness, headache, seizures, and the requirement for intubation, cerebrospinal fluid rhinorrhoea and otorrhoea. The secondary variables adopted were contusion, extradural haemorrhage, subdural haemorrhage, subarachnoid haemorrhage, pneumocephalus, cranial bone fracture and penetrating injuries.

Ethical clearance number given by Institutional Review Board is VIDS/ACM/406/2019. This study adhered to the guidelines laid down at the Declaration of Helsinki.

Results

A total of 90 patients were evaluated, of which 91.1% were males and 8.9% were females. A total of 57 patients were in between the age groups of 21 and 30 years [Table 1].

Of the 90 patients, 68 presented with fractures of a single bone whereas 22 patients had fractures in multiple bones in the maxillofacial region. The most common bone fracture was the zygomatic bone, with 49 patients having zygomatic complex fractures and 7 patients having fracture of only the zygomatic arch. The mandible and frontal bones were the second and third most common bone fractured with 32 and 19 cases being seen, respectively. Naso-orbito-ethmoid (NOE) fractures were most commonly seen in conjunction with frontal bone fractures [Table 2]. As per GCS, a total of 63 patients were diagnosed with mild TBI, 18 patients had moderate TBI and 9 patients had severe TBI.

On reporting to the Department of Emergency Medicine, patients were stabilised and thoroughly examined. The results of this examination showed a statistically significant association between fractures on the NOE complex as well as the frontal bone with TBI ($P \leq 0.001$). An association was also noted in fractures involving the condyle of the mandible, cranial bones as well as zygomatic arch [Table 3]. There was an association of clinical features of TBI being present in zygomatic complex fractures [Table 4].

On reviewing the association between the presence of clinical findings and head injury based on different regions of maxillofacial injuries using the Chi-square test, it was found that the upper and middle third of the face fractures have a higher incidence of TBI ($P = 0.001$) [Table 5].

A follow-up after 3 months of these patients showed patients with mild TBI were operated on average 2 days after the accident for maxillofacial fractures and showed a good prognosis. Patients with moderate TBI were kept for observation for a period of 5 days on the average following which were operated for maxillofacial fractures. It was seen that patients with severe TBI always needed immediate neurosurgical intervention where patients were taken up for emergency operations. The patients were then stabilised neurologically and operated only after neurosurgical clearance was given and the patient had a good prognosis. The patients who had a poor prognosis and GCS further fell were not taken for maxillofacial surgery but this was seen mostly in the severe TBI category.

Table 1: Age-wise distribution of study patients

Variable	Category	*n* (%)
Age (years)	<20	9 (10.0)
	21-30	57 (63.3)
	31-40	16 (17.8)
	41-50	3 (3.3)
	>50	5 (5.6)
	Total	90 (100.0)
	Mean (SD)	28.89 (9.39)
	Range	16-71
	Median	26 years

SD: Standard deviation

Table 2: Distribution of different facial bone fractures amongst study patients

Fracture	*n* (%)
Cranial bone	3 (3.3)
Frontal bone	19 (21.1)
NOE	8 (8.9)
Zygomatic complex	49 (54.4)
Zygomatic arch	7 (7.8)
Lefort 1	5 (5.6)
Parasymphysis of mandible	13 (14.4)
Symphysis of mandible	10 (11.1)
Angle of mandible	12 (13.3)
Condyle	13 (14.4)

NOE: Naso-orbito-ethmoid

Discussion

TBI is more common in young adults, particularly men (75%), which causes high costs to society because of life years lost due to death and disability.[7]

Comprehensive treatment of patients should be the utmost priority for a clinician. The relationship between maxillofacial trauma and brain injury being better understood, and delivering appropriate patient care has come into existence. The clinical signs of TBI being very mild are often unnoticed as well as lack of a detailed evaluation often leads to arriving at an inaccurate diagnosis.

The pattern of maxillofacial trauma and head injury in patients with craniofacial injuries was documented to identify whether craniofacial fracture patterns predispose patients with maxillofacial fractures to different types of intracranial haemorrhages. Patients were divided into three groups,

Table 3: Association between the occurrence of head injury and different maxillofacial bone fractures using the Chi-square test

Bone	Head injury	Absent, *n* (%)	Present, *n* (%)	*P*
Cranial bone	No	54 (100.0)	33 (91.7)	0.03*
	Yes	0	3 (8.3)	
Frontal bone	No	54 (100.0)	17 (47.2)	<0.001*
	Yes	0	19 (52.8)	
NOE	No	54 (100.0)	28 (77.8)	<0.001*
	Yes	0	8 (22.2)	
Zygomatic complex	No	29 (53.7)	12 (33.3)	0.07
	Yes	25 (46.3)	24 (66.7)	
Zygomatic arch	No	47 (87.0)	36 (100.0)	0.02*
	Yes	7 (13.0)	0	
Lefort 1	No	52 (96.3)	33 (91.7)	0.35
	Yes	2 (3.7)	3 (8.3)	
Parasymphysis of mandible	No	42 (77.8)	35 (97.2)	0.01*
	Yes	12 (22.2)	1 (2.8)	
Symphysis of mandible	No	48 (88.9)	32 (88.9)	1.00
	Yes	6 (11.1)	4 (11.1)	
Angle of mandible	No	44 (81.5)	34 (94.4)	0.08
	Yes	10 (18.5)	2 (5.6)	
Condyle	No	43 (79.6)	34 (94.4)	0.04*
	Yes	11 (20.4)	2 (5.6)	

*Statistically Significant. NOE: Naso-orbito-ethmoid

Table 4: Association between the occurrence of clinical findings and different maxillofacial bone fractures using the Chi-square test

Bone	Clinical finding	Absent, *n* (%)	Present, *n* (%)	*P*
Cranial bone	No	19 (100.0)	68 (95.8)	0.36
	Yes	0	3 (4.2)	
Frontal bone	No	18 (94.7)	53 (74.6)	0.07
	Yes	1 (5.3)	18 (25.4)	
NOE	No	19 (100.0)	63 (88.7)	0.13
	Yes	0	8 (11.3)	
Zygomatic complex	No	14 (73.7)	27 (38.0)	0.006*
	Yes	5 (26.3)	44 (62.0)	
Zygomatic arch	No	16 (84.2)	67 (94.4)	0.14
	Yes	3 (15.8)	4 (5.6)	
Lefort 1	No	19 (100.0)	66 (93.0)	0.23
	Yes	0	5 (7.0)	
Parasymphysis of mandible	No	13 (68.4)	64 (90.1)	0.02*
	Yes	6 (31.6)	7 (9.9)	
Symphysis of mandible	No	17 (89.5)	63 (88.7)	0.93
	Yes	2 (10.5)	8 (11.3)	
Angle of mandible	No	12 (63.2)	66 (93.0)	0.001*
	Yes	7 (36.8)	5 (7.0)	
Condyle	No	16 (84.2)	61 (85.9)	0.85
	Yes	3 (15.8)	10 (14.1)	

*Statistically Significant. NOE: Naso-orbito-ethmoid

Group A patients with maxillofacial fractures, Group B patients with head injury and Group C with combined craniofacial fractures. Group A had 53 patients, Group B had 38 patients and Group C had 39 patients. The most common intracranial haemorrhage in the present study was SDH. LeFort III fracture of the maxilla is mostly associated with intracranial haemorrhage.[8]

In a study, a total of 11,294 patients were classified as trauma patients, in which 176 patients had facial fractures and 292 did not have facial fractures were analysed. Mid-face fractures were the most common pattern of facial fracture seen. TBI was present in 36.7% of maxillofacial cases. A significant association was found between facial fractures and TBI. Patients with facial fractures had a 1.5 increased risk of having a TBI [Figure 1].[9]

A study demonstrated the relation between the type of maxillofacial fracture and type of TBIs, in which the majority of patients with epidural haemorrhage presented with mid-face fractures, while the minority of them presented with upper and lower face fractures. The majority of patients with subdural haemorrhage were associated with mid-face fractures, the majority of patients with brain contusions were associated with mid-face fractures and all of the patients presented by pneumocephalus were associated with mid-face fractures.[10]

In our study, we aimed to establish the incidence of head injury following maxillofacial fractures and to determine the association between the two. It was found that frontal and NOE fractures have the highest incidence of TBI. We recognised that pneumocephalus was a common finding in upper-third facial fractures. There is also an association between fractures and clinical signs of head injury being seen in cases of zygomatic complex fractures which gives a clear sign that a maxillofacial surgeon should suspect TBI in these conditions [Figure 2].

A study of 81 patients from two UK major trauma centres who sustained a fronto-basal fracture and were divided into two groups: those struck with predominantly anterior force and those by predominantly lateral force. The Glasgow Coma Score, the requirement for intubation and the requirement for decompressive craniectomy were used as markers of the severity of brain injury. An average Glasgow Coma Score of 5 was found in the lateral group and 14 in the anterior group; this difference was statistically significant. There was an increased need for both intubation and decompressive craniectomy in the lateral group compared to the anterior group.[11]

A study with the aim to find out which type of craniofacial traumas predispose to craniocerebral injuries and to analyse a relationship between the site of force application and the type of resultant craniocerebral injury was carried out as a retrospective study on 3481 patients with upper facial and mid facial traumas to determine the incidence of craniocerebral injury. The results of this study showed upper facial and zygomatic-orbital-maxillary complex fractures significantly more often coexisted with skull, dura mater or cranial nerve injuries and zygomatico-orbital fractures with injuries of the brain.[12]

The study done in our institution showed a high incidence of patients with fractures in the upper and middle one-third

Table 5: Association between the presence of clinical findings and head injury based on different regions of maxillofacial injuries using the Chi-square test

Variables	Category	Upper facial, *n* (%)	Mid facial, *n* (%)	Lower facial, *n* (%)	*P*
Clinical findings	Absent	1 (5.6)	7 (14.9)	11 (44.0)	0.003*
	Present	17 (94.4)	40 (85.1)	14 (56.0)	
Head injury	Absent	0	32 (68.1)	22 (88.0)	<0.001*
	Present	18 (100.0)	15 (31.9)	3 (12.0)	

*Statistically Significant

of the face showing clinical features as well as radiographic interpretation of TBI. To assess and identify life-threatening conditions in patients with maxillofacial fractures accompanied by head injury, it is imperative to have a detailed and thorough clinical and radiological assessment and this would help in elucidating an effective management strategy.

This study would aid in formulating a diagnostic protocol which will assist in the thorough assessment of patients who are at a higher risk of TBI. Adapting the abovementioned would probably provide a better prognosis in such patients and would also aid further research work in the area of traumatic head injury by giving researchers a guideline to follow as well as show them at-risk groups who should be reviewed more carefully.

The limitation of this study is we do not have a longer than 3-month follow-up to look at the long-term effects of TBI. Another limitation is GCS can be interpreted wrongly if the patient is under the influence of drugs or alcohol which could prevent the correct categorisation of these patients.

Conclusion

A definite relationship between maxillofacial fractures and TBI is being proven. Patients with frontal bone and zygomatic bone fractures have a prevalence of TBI. Patients with multiple bone fractures of the maxillofacial region are at a higher risk for TBI and should be thoroughly evaluated for the same. It is important for a maxillofacial surgeon to identify such patients and also to have a hawks eye in picking up the positive clinical signs, which otherwise can be overlooked. These would eventually help in providing the best and effective management possible as far as patient care is concerned.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Pappachan B, Alexander M. Correlating facial fractures and cranial injuries. J Oral Maxillofac Surg 2006;64:1023-9.
2. Joshi UM, Ramdurg S, Saikar S, Patil S, Shah K. Brain injuries and facial fractures: A prospective study of incidence of head injury associated with maxillofacial trauma. J Maxillofac Oral Surg 2018;17:531-7.
3. Abosadegh MM, Rahman SA. Epidemiology and incidence of traumatic head injury associated with maxillofacial fractures: A global perspective. J Int Oral Health 2018;10:63-70.
4. Ruslin M, Wolff J, Yusuf HY, Arifin MZ, Boffano P, Forouzanfar T. Use of neuron-specific enolase to predict mild brain injury in motorcycle crash patients with maxillofacial fractures: A pilot study. Chin J Traumatol 2019;22:47-50.
5. Choonthar MM, Raghothaman A, Prasad R, Pradeep S, Pandya K. Head injury- a maxillofacial surgeon's perspective. J Clin Diagn Res 2016;10:E01-6.
6. Hammond D, Welbury R, Sammons G, Toman E, Harland M, Rice S. How do oral and maxillofacial surgeons manage concussion? Br J Oral Maxillofac Surg 2018;56:134-8.
7. Maas AI, Stocchetti N, Bullock R. Moderate and severe traumatic brain injury in adults. Lancet Neurol 2008;7:728-41.
8. Sandhya K, Bobby J, Vincia P. Interrelation of maxillofacial fractures and cranial injury – A prospective study. Int J Appl Dent Sci 2017;3:162-4.
9. Rajandram RK, Syed Omar SN, Rashdi MF, Abdul Jabar MN. Maxillofacial injuries and traumatic brain injury – A pilot study. Dent Traumatol 2014;30:128-32.
10. Elbaih AH, El-Sayed DA, Abou-Zeid AE, Elhadary GK. Patterns of brain injuries associated with maxillofacial fractures and its fate in emergency Egyptian polytrauma patients. Chin J Traumatol 2018;21:287-92.
11. Stephens JR, Holmes S, Bulters D, Evans BT. The effect of direction of force to the craniofacial skeleton on the severity of brain injury in patients with a fronto-basal fracture. Int J Oral Maxillofac Surg 2016;45:872-7.
12. Błaszczyk B, Studziński M, Ładziński P. Coincidence of craniocerebral and craniofacial injuries. J Craniomaxillofac Surg 2019;47:287-92.