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Frontal Bone Fractures Associated with Maxillofacial Trauma -Patterns & Incidence

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Abstract:
Background: *Traumatic head injuries, including maxillofacial fractures, present a significant global health challenge, with road traffic accidents being a major contributing factor, especially among males. This study investigates the complex relationship between facial fractures and head injuries, exploring varying perspectives on whether facial bones protect or transmit forces to the cranial region. The research highlights the high incidence of neurological complications in individuals with facial fractures, emphasizing the importance of early recognition and appropriate management.*
Materials and Methods: *A total of 270 patients were included in the study. The study investigated the presence and patterns of head injuries in patients with associated maxillofacial fractures, assessing brain injuries using the Glasgow Coma Scale (GCS) and*
confirming them with CT scans, which also helped detect spinal injuries. Trauma-causing facial fractures were attributed to various factors, such as road traffic accidents, falls, sports injuries, assaults, workplace accidents, bicycle accidents, penetrating injuries, andgunshot wounds.
Results: *In our study of 270 maxillofacial fracture patients, Male predominance is the most common within the age group 0f 10 to 80years with a history of RTA. Among 70 patients of frontal-bone associated maxillofacial fracture the most common fractured bone is the 17(12.14%) maxillary bone followed by 15 (10.71%) nasal bone fractures.*
Conclusion: *In conclusion, this study highlights the risk of head injury increased significantly with an increase in the number of facialfractures. There was an association between head injury and maxillofacial trauma.*
Keywords: *Facial fractures - Incidence - Head injury*

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I. Introduction

Worldwide, there are many traumatic head injuries annually. Traumatic head injury is a major cause of morbidity, mortality, and disability and is associated with significant economic and social impact in both developed and underdeveloped countries.[1]

Historically, facial architecture has been considered a cushioning the neurocranium from severe damage. That is the faceprotects (prevents) the brain from external injury. [2]

The proximity of maxillofacial bones to the cranium would indicate that there are negligible chances of traumatic brain

injuries occurring simultaneously with facial fractures. Recent investigations have suggested that the face may actually transmit forcesdirectly to the neurocranium, resulting in simultaneous brain injuries.[3]

The precise nature of injury to the cranio maxillofacial region is determined by the degree of force and the resistance to the forceoffered by the craniofacial bones. The severity of it is expressed by the direction and the point of application of the force.[4]

Skull Vault fractures are common injuries observed in the direct of both blunt and penetrating trauma.

Maxillofacial injuries may be limited to superficial lacerations, abrasions over the face and also may be associated withmultiple injuries to the head, chest, abdomen, cervical spine or extremities.[3]

The maxillofacial region can be divided into three parts: (i) the upper face – the frontal bone and frontal sinus (ii) the midface – the nasal, ethmoid, zygomatic, and maxillary bones; and (iii) the lower face – the mandible.[5]

Facial fracture classification can affect multiple or single bones of the face. Because of the area's complexity, it is not

always easy for the surgeon to classify facial fractures based on the bone involved. [6] Naso-orbital-ethmoid (NOE) fractures, Nasal fractures, orbital wall fractures, maxillary sinus fractures, Le Fort I fracture, Le Fort II fracture, and Le Fort III fracture as midface fractures. Orbital floor, Zygomatic malar complex, arch fracture as lateral midface fractures and symphysis, mandibular condyle, coronoid process, ascending ramus, angle, horizontal or body ramus, and alveolar process as mandibular fractures.[7]

Injuries can be incurred in situations such as the road traffic accidents, fall from height, interpersonal violence, animalattacks and sports.[8]

Early recognition of associated head injuries remains an important part of initial assessment and treatment planning in maxillofacial trauma patients. Prompt determination of head injuries is crucial to prevent morbidity and mortality. Hence, the need toknow about the cranial injuries associated with maxillofacial injuries becomes important.[9]

This study therefore evaluates the individuals with traumatic injuries to the maxillofacial skeleton from different mechanisms. And to calculate the patterns and incidence of frontal fracture associated with maxillofacial fracture.[10]

II. Patients and Methods

Participants and Procedures:

A total of 270 individuals who had sustained head injuries and were reported to the emergency unit at Dr. Muthu's Hospital, Singanallur, were enrolled in our retrospective study conducted over 8 months from February 2023 to September 2023.

Demographics and Injury Details:

We recorded demographic information, including age and gender, as well as the cause of trauma and details of maxilla facial injuries.

Classification of Maxillofacial Fractures:

Maxillofacial fractures were categorized based on their anatomical location, including nasal fractures, maxillary fractures, mandibular fractures, frontal bone fractures, lower orbital rim fractures, and zygomatic fractures. These diagnoses were established through primary clinical assessments, complemented by CT scans.

Concomitant Head Injuries:

We also investigated the occurrence and patterns of head injuries in patients who had maxillofacial fractures associated withtheir head trauma.

Assessment of Head Injuries:

Additionally, we assessed patients for any coexisting head injuries. Brain injuries were clinically suspected using the Glasgow Coma Scale (GCS) and subsequently confirmed through CT scans, which were also employed to detect spinal injuries.

Cause of Fractures:

The etiology of trauma to facial bone occurs due to Road traffic Accidents, Falls, Sports Injuries, Assaults, WorkplaceAccidents, Bicycle Accidents, Penetrating Injuries and Gunshot Wounds.

III. Result

A total of 270 patients who reported to the emergency unit (casualty) at Dr. Muthu's Hospital, Singanallur, Coimbatore, Tamil Nadu with a varied history of trauma ranging from simple fall to road traffic accident (RTA) were examined.

Patients of maxillofacial fractures with associated head injuries were further categorized into four groups:

1. Cases that return to normal conscious level within 6 h were classified as concussion injury and cerebral edema.
2. Intracranial hematoma group: Cases with subarachnoid hematoma, subdural hematoma, epidural hematoma and intracerebralhaemorrhage.
3. Skull fracture group: Cases with pneumocephalus and skull base fractures.
4. Cerebral contusion group: Cases with cerebral contusion and laceration.

The demographic profile revealed the distribution of head injury according to sex showing 231 male patients and 39 femalepatients. The chi-square test shows that there is a significant difference in the type of head injury between the genders. Men are significantly more affected by Frontal associated maxillofacial fracture as compared to women and females are significantly more affected by Nasal fracture when compared to males. (Table 1 & Figure 1)

Based on Glasgow Coma Scale (GCS) scoring, the patients were categorized into three groups: group I: 3–8 score, severehead injury; group II: 9–12 score, moderate head injury; and group III: 13–15 score, mild head injury. Based on these scoring, moderate head injury in 41 patients and mild head injury in 229 patients out of 270 patients (Table 2)

The chi-square test shows there is a significant association between age and Type of head injury. Children below 10 years of age never sustained an injury in the study. Those between 10-30 years of age sustained Subdural hematoma significantly less than other elderly age groups. (Table 3 &Figure 2)

Among all the patterns of head injury cases, concussion accounts for about 39(34.51%) patients, followed by contusion 27 (23.89%) patients followed by Subdural hematoma 28(24.78%) patients out of 113 patients then followed by SAH, EDH, Pneumocephalus etc. (Table 4 &Figure 3)

Among all the head injury frontal bone fracture are the most occurring which accounts for about 70 (39.33 %) patients followed by nasal bone fracture 50 (28.09%) patients, followed by zygomatic arch fracture and mandible fractures. (Table 5 & Figure4)

In our study out of 70 frontal bone fracture associated with maxillofacial fracture patients ,17 (12.14%) patients account formaxillary fracture followed by nasal bone fracture 15(10.71%) followed by other fractures. (Table 6 & Figure 5)

Our study reveals, 55 Out of 195 patients sustained head injury with only one fracture followed by 90 patients with twofractures and then followed by 50 patients with three or more associated fractures (Table 7 & Figure 6)

TABLE 1:

Type of head injury	Males		Females		P value
	N	%	N	%	
Epidural hematoma	8	3.46	1	2.56	0.003
Frontal associated maxillofacial fracture	68	29.44	2	5.13	
Maxillofacial fracture	38	16.45	4	10.26	
Nasal	30	12.99	12	30.77	
No fracture	62	26.84	13	33.33	
Subdural hematoma	25	10.82	7	17.95	
Total	231	100	39	100	

TABLE 2:

GCS Score	N	%
3-8	0	0
9-12	41	15.19
13-15	229	84.81

TABLE 3:

Type of head injury	< 10 years		10-30 years		31-50 years		>50 years		P value
	N	%	N	%	N	%	N	%	
Epidural hematoma	-		3	2.73	2	2.27	4	6.56	0.002
Frontal associated maxillofacial fracture	-		24	21.82	25	28.41	13	21.31	
Maxillofacial fracture	-		21	19.09	14	15.91	7	11.48	
Nasal	-		21	19.09	9	10.23	12	19.67	
No fracture	3	100	34	30.91	21	23.86	17	27.87	
Subdural hematoma	-		7	6.36	17	19.32	8	13.11	
Total	3	100.0	110.00	100	88	100	61	100	

TABLE 4:

TYPE OF HEAD INJURY	No of patients	
	N	%
Subarachnoid hemorrhage	4	3.54
Subdural hematoma	28	24.78
Epidural hematoma	7	6.19
Intracerebral hematoma	2	1.77
Contusion	27	23.89
Concussion	39	34.51
Skull base fracture	4	3.54
Pneumocephalus	2	1.77

TABLE 5:

Type of maxillofacial injury	Number of patients	
	(n)	%
Frontal bone	70	39.33
Nasal bone	50	28.09
Zygomatico-maxillary complex	2	1.12
Zygomatic arch	14	7.87
Infraorbital	9	5.06
Lefort I	0	0.00
Lefort II	0	0.00
Lefort III	1	0.56
Mandible	12	6.74
Pan facial	2	1.12
Fronto-zygomatic suture	7	3.93
Condyle	4	2.25
Maxilla	7	3.93

TABLE 6:

Type of frontal bone fracture associated with maxillofacial fracture	Number of patients	
	N	%
Frontal bone	70	50.00
Nasal bone	15	10.71
Zygomatico-maxillary complex	3	2.14
Zygomatic arch	7	5.00
Maxilla	17	12.14
Mandible	1	0.71
Pan-facial	1	0.71
Infraorbital	7	5.00
Frontozygomatic suture	9	6.43
Condyle	3	2.14
Lefort III	1	0.71
No maxillofacial fracture	6	4.29

TABLE 7:

ASSOCIATION BETWEEN MAXILLOFACIAL INJURIES AND HEAD INJURIES	Number of patients	
	N	N
ONE FRACTURE	55	28.21
TWO FRACTURES	90	46.15
THREE OR MORE FRACTURE	50	25.64

FIGURE 1:

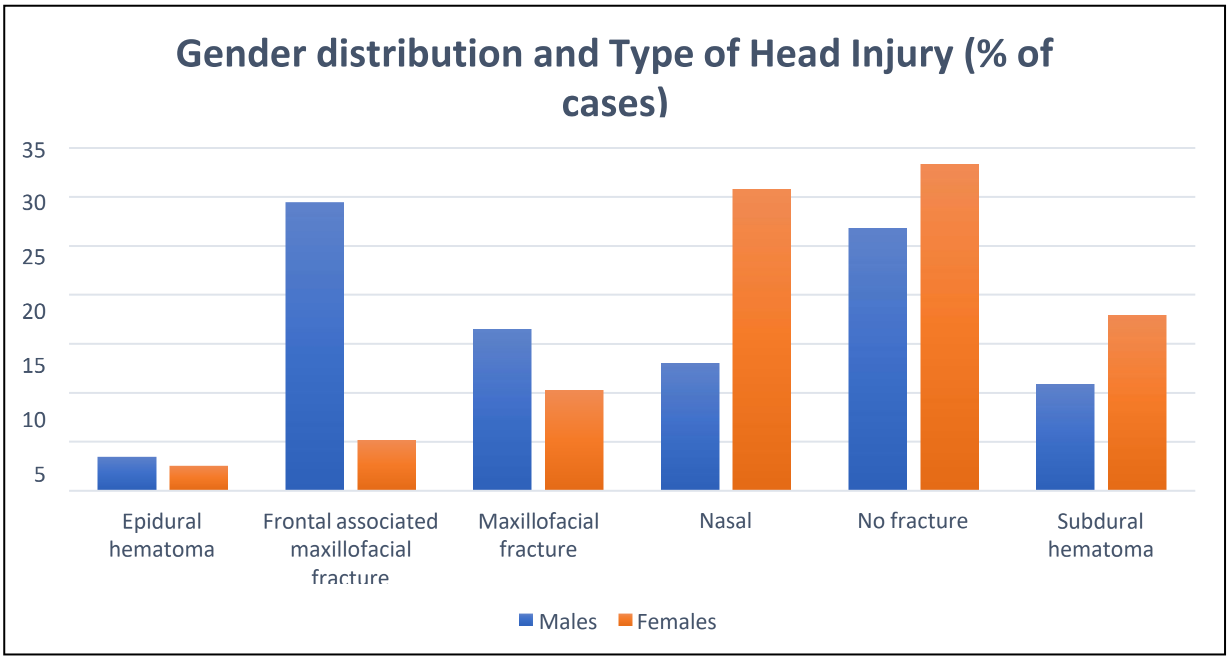


FIGURE 2:

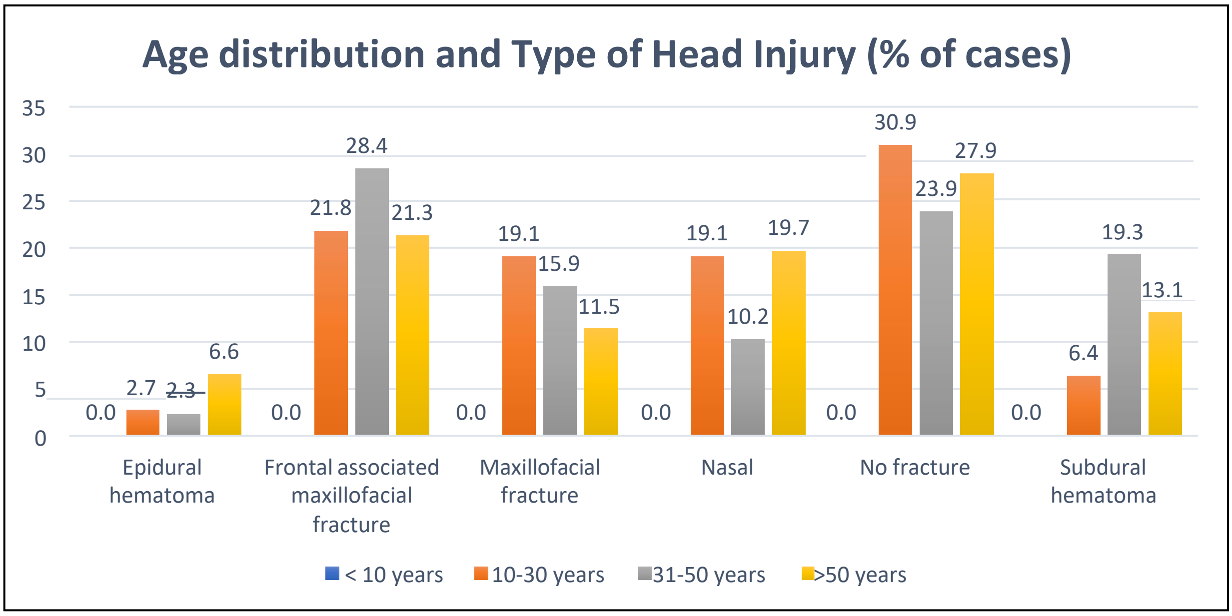


FIGURE 3:

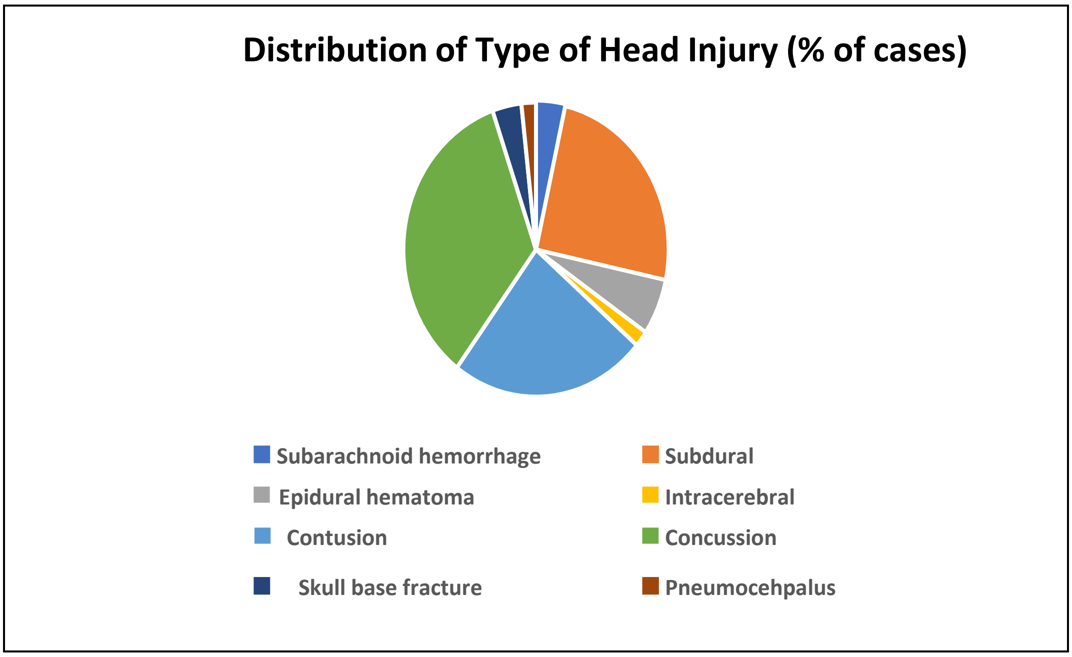


FIGURE 4:

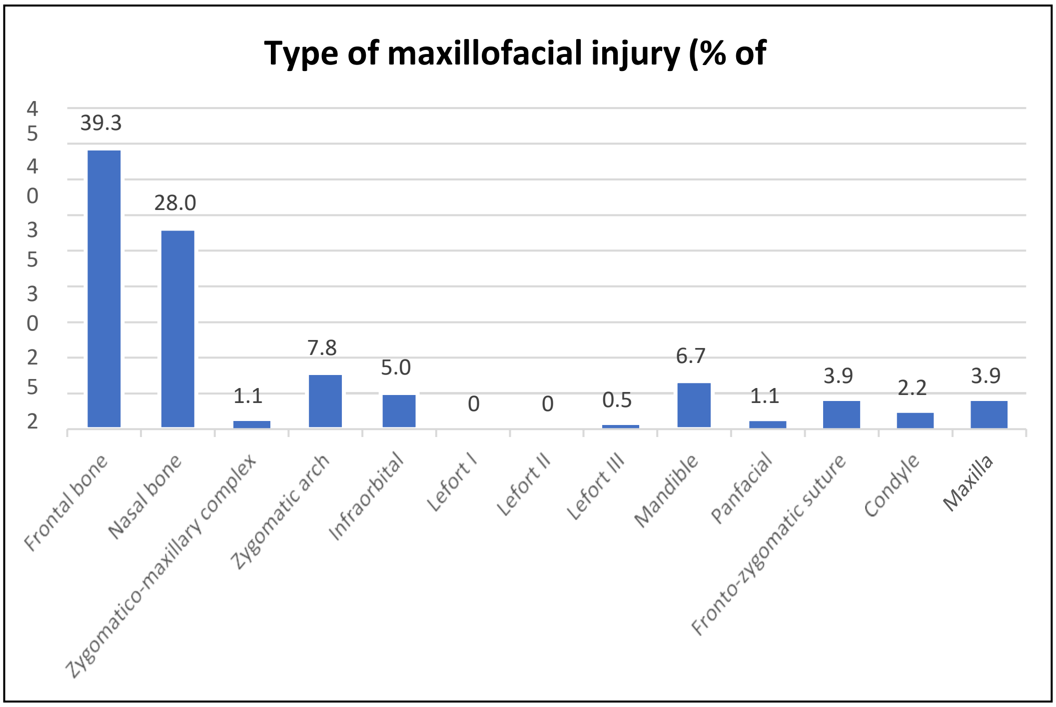


FIGURE 5:

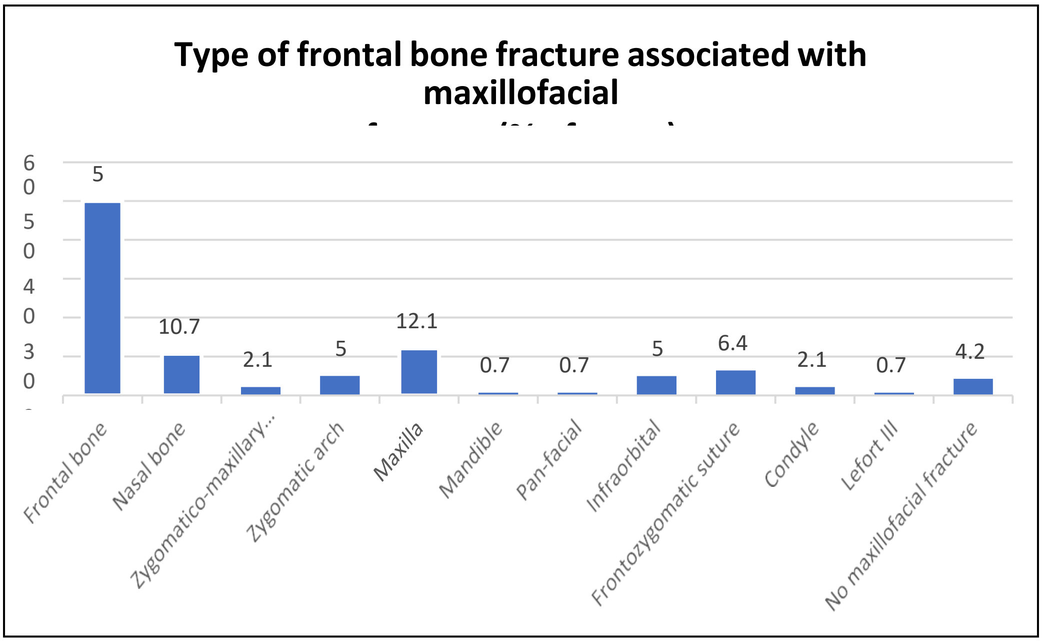
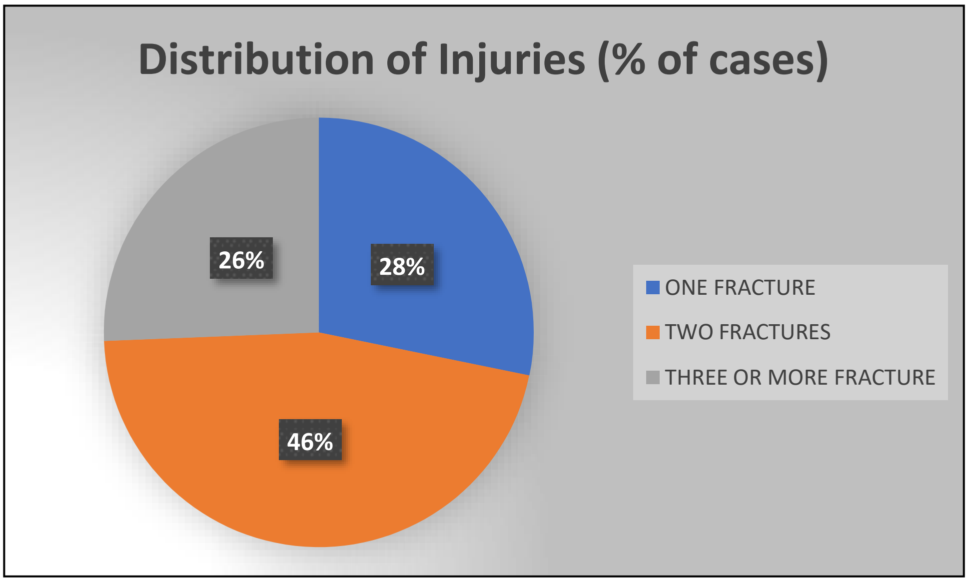


FIGURE 6:



IV. Discussion

In developing countries, road traffic accidents are a significant public health concern, particularly impacting younger generations. These accidents often lead to various injuries, with maxillofacial injuries being common, and more than half of these patients have multiple injuries affecting different parts of their bodies. Multisystem trauma management requires collaboration amongspecialists, including neurosurgeons, maxillofacial surgeons, ENT specialists, and ophthalmologists. Maxillofacial injuries are complex to manage, involving both physical and aesthetic considerations. Head and cervical spine injuries are particularly critical, with primary head injuries resulting from the initial impact, and secondary injuries caused by processes like inflammation, bleeding,or swelling within the brain. Preventing and effectively managing secondary injuries is crucial for patient outcomes. Road safety education and improved infrastructure play a vital role in reducing the frequency and severity of road traffic accidents in developingcountries.[11]

The study identified road traffic accidents as the primary cause of injuries, aligning with the results of several other studies.

Self-falls were the second most frequent cause of trauma, with interpersonal violence following closely. This finding was alsosubstantiated by Scherbaum Eidt et al. in their own study.[12]

The facial skeleton can experience different forces from various directions, such as front to back, top to bottom, bottom to top,and from the sides. These forces, combined with the level and point of impact, determine the pattern of injury. It's rare for fractures originating in the cranium to extend into the facial skeleton. However, fractures originating in the facial skeleton can extend into the cranium, specifically fractures of the frontal bone, the cribriform plate of the ethmoid, and temporal bone. Analyzing the mechanism of injuries sustained during road traffic accidents can help us understand the impact of these displacing forces. The concept of "bonypillars" in the midfacial skeleton suggests that these bones can absorb a significant amount of force from below, but they can be relatively easily fractured by even minor forces from other directions. Researchers have studied the tolerance levels of individual bones in the midface and mandible. For instance, the nasal bones are the most fragile, with minimal fracture tolerance levels in the range of 25 to 75 pounds. The maxilla has a low tolerance level in the range of 140 to 445 pounds, primarily due to its relatively thinanterior wall. The zygomatic arch is relatively fragile, with tolerance levels between 208 and 475 pounds, while the body of the zygoma can withstand more force, falling in the 200 to 450-pound range. The massive frontal bone, found in the forehead area, hasthe highest tolerance levels, with a range of 800 to 1600 pounds. It's important to note that the mandible is more sensitive to lateralimpacts compared to frontal ones.[13]

Lee and colleagues suggested that facial fractures might decrease the risk of traumatic brain injury. They proposed that thefacial bones could act as a protective cushion for the brain, explaining why injuries that crush facial bones often do not result in apparent brain damage. Davidoff and collaborators found a strong association between facial fractures and traumatic brain injuries. Their research indicated that facial fractures were frequently linked to traumatic brain injuries. Chang and colleagues suggested that central craniofacial fractures, particularly involving the maxilla, play a crucial role in protecting the brain from direct collision by absorbing impact energy. They emphasized a direct correlation between the severity of maxillary fractures in the central craniofacial area and the initial head injury. The association of zygoma fractures with other cranial bone fractures has varied across studies. Haug et al found that zygoma fractures were frequently associated with fractures of cranial bones connected by sutural attachments, such as the frontal, sphenoid, and temporal bones, and disagreed with the theory of facial bones acting as a protective cushion for the cranium.They stressed that midfacial bones transmit the force of impact directly to the cranium. The relationship between mandibular fractures and cranial injuries also varies. Haug et al found that mandibular fractures were associated more frequently with closed head injuries and did not show a significant link between mandibular fractures and cranial fractures. Other studies, however, have found significantassociations between mandibular fractures and cranial injuries.

In the study conducted by Haug and colleagues, it was discovered that around one-third of patients who experienced facial fractures also had some type of neurological injury. Initially, this may have seemed like a high incidence rate. However, upon a morecomprehensive review of existing literature, it became evident that the frequency of neurological injuries linked to facial fractures could be as high as 76%. This finding underscores the significant association between facial fractures and neurological issues,shedding light on the importance of recognizing and addressing these injuries in clinical practice.[14]

More recently, Keenan and associates contraindicated the idea that facial fractures prevent traumatic brain injuries. They reported that the risk of intracranial injury in individuals with facial injuries increased significantly, almost tenfold. Moreover, the riskfor all types of brain injuries, including concussions, doubled in these cases.

Maxillofacial injuries seen in trauma units encompass a wide spectrum of conditions, ranging from dento-alveolar fractures,nasal bone fractures, mandibular fractures, maxillary fractures, frontal bone fractures, naso-orbito-ethmoid fractures, pan facial fractures, to penetrating injuries. These injuries can be quite diverse and complex, often occurring in combination with intracranial,pulmonary, intra-abdominal, or extremity injuries in the same patient.[15]

The anatomical structure of certain facial bones, such as the orbital wall, zygomatic, nasal, and maxillary sinus wall bones,makes them more prone to fractures, especially in high-velocity trauma situations. These bones are characterized by their hollow, cancellous nature and relatively thin structure, rendering them more susceptible to damage compared to the mandibular bone.

Additionally, the proximity of mid-face bones to the cranium increases the risk of rupturing intracranial vessels, potentially leading tolife-threatening intracranial hemorrhages. Therefore, these injuries not only pose challenges due to their diverse nature but also due tothe potential severity of associated complications.[16]

In cases of suspected cranial injury, typical indicators include amnesia, vomiting, loss of consciousness, or a low GlasgowComa Scale (GCS) score. However, it's worth noting that in patients with maxillofacial trauma, head injuries can occur even in the absence of these common signs and symptoms. This is a significant concern because the presence of head injuries in individuals with maxillofacial trauma can be life-threatening and increase the risk of mortality. Despite the critical nature of this issue, the precise relationships between various types of facial fractures and brain injuries have not been conclusively established in existing studies, asnoted by Fonseca et al. This highlights the need for further research to better understand these relationships and improve the management of patients with maxillofacial trauma who may also be at risk of underlying head injuries.

In our studies, we reported 3 patients who were children i.e. below 10 years. Aetiology was due to self-fall, RTA.

Children are uniquely susceptible to craniofacial trauma because of their greater cranial-to-body mass ratio. The reasons for the lowerincidence of facial fractures in children can be concluded as the face is smaller about the rest of the head, there is a lower proportion of cortical bone to cancellous bone in the children's faces, poorly developed sinuses make the bones stronger, and fat pads provide protection for the facial bones

In our study, we found statistical association between head injury and maxillofacial trauma, p-value of 0.002 The risk and severity of head injury increased as the number of facial fractures increased. In our study, facial fractures did not prevent head injuries but were markers for an increased likelihood of head injuries. This is in correlation with studies reported but in contrast to studies whosuggested that facial bones act as a protective cushion for the brain, explaining the fact that injuries that crush the facial bones frequently cause no apparent brain damage. Chang et al. suggested that the maxilla, together with the neighbouring bones, is capable of absorbing considerable impact force, thus protecting the brain from direct collision.

The occurrence of Subdural hematoma was significantly lower in the age range of 10-30 years when compared to the olderage groups. Among the various head injury patterns, concussion was the most common, affecting about 39 individuals, comprising 34.51% of the cases. Following closely was a contusion, which impacted 27 individuals, accounting for 23.89% of the total cases, while Subdural hematoma affected 28 patients, representing 24.78% of the 113 patients in the study. Beyond these findings, the dataset included cases of SAH, EDH, Pneumocephalus, and other head injury categories.

Among 270 patients, mostly noted fracture was frontal bone fracture which accounted for about 70 (39.33 %) patients followed by nasal bone fracture 50 (28.09%) patients, followed by zygomatic arch fracture14(7.87%) and mandible fractures12(6.74%). In our study out of 70 frontal bone fracture associated with maxillofacial fracture patients ,17 (12.14%) patients account for maxillary fracture followed by nasal bone fracture 15(10.71%) followed by other fractures. There was no isolated frontalbone fracture was evaluated. 55 Out of 195 patients sustained head injury with single bone fracture followed by 90 patients involvingtwo bone fractures and then followed by 50 patients with three or more bone fractures.

Secondly, this study suggests that it is incorrect to view the fractures to the facial skeleton as an isolated one, because, itis, as evidentially established in this study, associated with more grave, and sometimes fatal head injuries that require thorough evaluation at the time of presentation. Surgical management of such traumatized patients with head and neck trauma is highly individualized and depends on several factors including etiology, concomitant injuries, age of the patient and the possibility of aninterdisciplinary procedure. This study facilitates the conclusion that knowledge of the associated injuries ensures proper care and faster recovery. Only a multidisciplinary and coordinated approach can vouch for optimum success in the treatment of patients with facial fractures with associated injuries.[15]

V. Conclusion

In conclusion, this study sheds light on the critical issue of road traffic accidents which is the main etiology and their impact on publichealth in developing countries, especially among male individuals. The study reveals the intricate relationship between facial fractures and head injuries, with varying opinions on the protective role of facial bones. It underscores the high incidence of neurological issues in patients with facial fractures, highlighting the need for recognition and management.

Individuals aged 10-30 years exhibited notably lower instances of Subdural hematoma when compared to older age groups. Among the various head injury patterns, the most prevalent is concussion, affecting approximately 39 individuals, constituting 34.51% of the cases. Following closely is contusion, affecting 27 individuals, making up 23.89% of the cases, while Subdural hematoma accounts for 28 patients, representing 24.78% of the 113 total patients. Subsequently, we observed instances of SAH, EDH, Pneumocephalus, and other head injury types.

In our study involving 270 maxillofacial fracture patients, frontal bone fractures were the most prevalent (39.33%), 12.14% also hadassociated maxillary fractures. However, there are no isolated frontal bone fractures noted. Regarding the number of fractures, 55 patients had one bone fracture, 90 had two bone fractures, and 50 had three or more bone fractures.

Overall, this research underscores the importance of a multidisciplinary and coordinated approach in the treatment of patients with facial fractures and associated injuries, ensuring proper care and faster recovery. It contributes to our understanding of the complex interplay between facial and head injuries and the need for a comprehensive approach to trauma management in clinical practice.

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