Analysis of Maxillofacial Injuries of Vehicle Passengers Involved in Frontal Collisions

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Abstract

Traffic accident is the leading cause of maxillofacial injuries. Because patients with these injuries often develop disabilities and require long-term treatment, research into maxillofacial injuries and the promotion of appropriate preventive measures are needed to improve these patients' welfare. To clarify the incidence and mechanisms of maxillofacial injuries sustained by motor vehicle passengers, we retrospectively analyzed in-depth data from the Institute for Traffic Accident Research and Data Analysis (ITARDA), Japan.

From the ITARDA in-depth data for 1993 through 2005, data was collected for 226 individuals with maxillofacial injuries who were adult passengers involved in frontal motor vehicle collisions. The mean injury severity score was 5.7 $\pm$ 8.3, and the mean equivalent barrier speed of the vehicles was 35.2 $\pm$ 13.0 km/h. The most common maxillofacial injuries were lacerations (46.7%), followed by abrasions (41.9%), fractures (14.0%), and dental injuries (5.7%). Maxillofacial fractures occurred more often in unrestrained drivers without airbag deployment (18.4%) and less in restrained drivers with airbag deployment (4.3%).

We found that the prevalence and severity of maxillofacial injuries vary with differences in seating position and in the use of safety devices. Because these injuries are also associated with socioeconomic costs, further research on maxillofacial injuries among traffic collision victims should be promoted.

Introduction

Motor vehicle collisions are the leading cause of maxillofacial injuries and are among the most frequent cause of facial fractures [1-3]. When patients sustain moderate to severe maxillofacial injuries, such as fractures, they often develop disabilities and require long-term treatment. Thus, preventing maxillofacial injuries is a valuable pursuit for both improving the quality of life of the involved patients and decreasing the socioeconomic costs of motor vehicle collision injuries. Comprehensive research to integrate information from collision details and on human injuries is needed when considering the prevention of moderate to severe maxillofacial injuries.

The present research clarifies patterns and the severity of facial injuries, the impact sites that caused the injuries, and the characteristics of the collision events, then suggests how the use (or lack) of safety devices affected the outcomes.

Materials and Methods

Data collection

Samples were collected from the data records of the Institute for Traffic Accident Research and Data Analysis (ITARDA). In carrying out its in-depth analysis of actual events, ITARDA's specialized investigators visit the scene of recent collisions to interview the individuals involved and to examine the vehicles and traffic situations. External damage profiles of the involved vehicles are prepared, internal vehicle intrusions and contact marks are documented, and the equivalent barrier speed (EBS) of the involved vehicles are calculated from the damage measurements and the known weight of the vehicles. Field data is also collected on many different aspects including emergency rescue and medical conditions. Then, details on physical injuries and the general condition of each patient, both before and after the collision, are obtained.

Data on adult vehicle passengers (over 17 years old) with any maxillofacial injuries that score one or higher on the Abbreviated Injury Scale (AIS), who were involved in a frontal collision from 1996 to 2005, were collected from in-depth data of ITARDA. The involved vehicles were limited to passenger cars including sedans, sport-utility vehicles and light trucks (heavy vehicles were excluded). "Frontal collision" was defined as the principal direction of force being directly from the front of the vehicle, plus or minus 45°. The following data were collected from collision reports: how and where the collision occurred, the type of vehicle involved, the EBS of the vehicle at time of impact, the seating position of the patient, and whether airbags were deployed. Referring to the patient's medical data, age, and physical stature (body height, weight, and body mass index), the data on the injured region and the injury pattern were examined. Furthermore, in reviewing the injury data, objective measures of injury severity - the injury severity score (ISS) and the 1990 revision of the Abbreviated Injury Scale (AIS) - were calculated for each patient [4, 5]. Seatbelt use was also determined through interviews with the victims and examination of evidence during the collision inspection, such as markings on the belt webbing or the D-ring, which indicate loading in a crash. Collision cases were excluded from analysis if information regarding the direction of impact, the point of collision, or the status of seatbelt use was missing.

Statistical analysis

One-way analysis of variance was used to compare differences in the mean age of the patients, and the AIS or ISS values between four groups, categorized by use of safety devices. The chi-square test was used to compare the frequencies of various types of injuries between the different groups. Differences with a p-value less than 0.05 were considered significant.

Results

1) General aspects

From the 3631 cases of in-depth collision data investigated by ITARDA over 10 years, a total of 226 patients (157 male and 69 female) from 205 collisions were reviewed for this study. One hundred and fifty three patients were involved in car-to-car collisions and 73 were collisions with other objects. Most of the patients (83.6%) were drivers, followed by front-seat passengers (9.6%) and rear-seat passengers (6.6%). Their ages ranged from 18 to 84, with a mean of 33.3 $\pm$ 14.9. Regarding the physical stature of the patients, their mean height was 165.8 $\pm$ 8.0 cm (ranging from 145.0 to 183.0), mean weight was 60.7 $\pm$ 10.7 kg (ranging from 38.0 to 105.0), and mean body mass index was 21.9 $\pm$ 3.1 (ranging from 16.6 to 39.5).

2) Patients' injury severity

The ISSs ranged from 1 to 50 (mean: 5.7 $\pm$ 8.3). Ninety-four patients had an ISS of 1, and 40 had an ISS of 2, together accounting for 59.3% of all patients (Fig. 1). In comparing injured body regions, the face was the region with the highest AIS score (1.1 $\pm$ 0.3), followed by the lower extremities (0.7 $\pm$ 0.9), head/neck (0.5 $\pm$ 1.0), chest (0.5 $\pm$ 1.1), and upper extremities (0.4 $\pm$ 0.7). For the face, most of the injuries (89.8%) were coded with an AIS of 1, while 9.7% had an AIS of 2 and 0.4% had an AIS of 3.

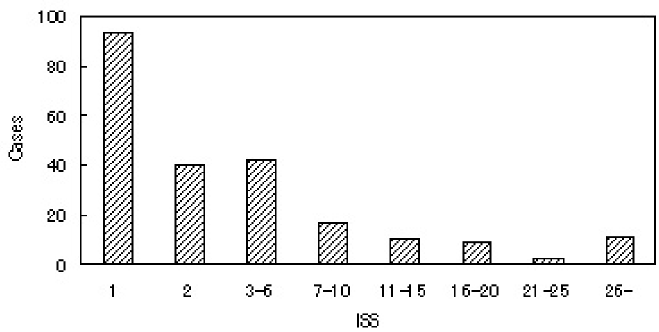

Fig. 1 Distribution of ISS

3) Analysis of facial injuries

Regarding the types of maxillofacial injuries in all patients, lacerations occurred in 46.7% of all patients, followed by abrasions (41.9%), fractures (14.0%), dental injuries (5.7 %), oral cavity injuries (3.1%), and others (1.7%) (Fig. 2). For maxillofacial fractures, the incidence distribution of the fractured sites is as follows: nasal fractures (38.5%), maxillary fractures (25.6%), mandible fractures (17.9%), zygomatic fractures (10.3%), and orbital fractures (7.7%) (Fig. 3). As for the impact site of the vehicle interior, the steering was most common (53.8%), followed by the instrument panel (28.2%), windshield (10.3%), and A-pillar (7.7%).

Because the majority of the patients in our study were vehicle drivers, they were used as the focus of our analysis (described below).

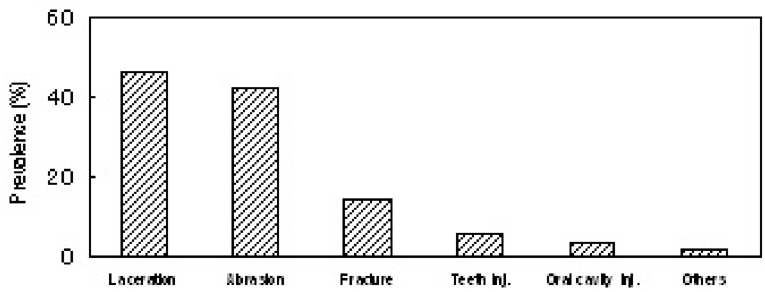

Fig. 2 Prevalence of the type of maxilofacial injuries

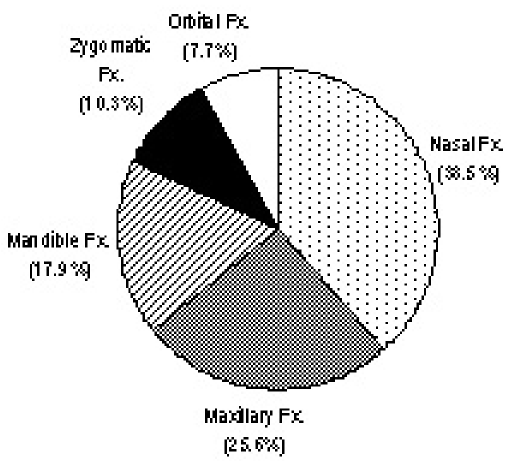

Fig. 3 Distribution of maxillofacial fractures

4) Effect of safety devices for drivers

We subdivided the 189 drivers according to safety restraint use. Restraint classifications were based on airbag deployment in combination with whether the seatbelt was used. Thus, four categories were examined: unrestrained (87 cases), seatbelt only (60 cases), airbag only (19 cases), and both seatbelt and airbag (23 cases). The mean age and mean BMI of the patients, as well as mean EBS of the involved vehicles are shown in Table 1. For these items, no statistically significant differences were found between the four groups (ANOVA, $p>0.05$). First, the ISS and AIS of the face were compared. The mean ISS ranged from 4.2 to 7.7 and the AIS of the face ranged from 1.0 to 1.1, but neither showed statistically significant differences (ANOVA, $p>0.05$). Next, the prevalence of patients with maxillofacial fractures was compared between the four groups. Unrestrained drivers were the ones to most frequently sustain maxillofacial injuries (18.4%), followed by drivers using a seatbelt only (10.0%), those with airbag only (5.3%) and those with both seatbelt and airbag (fully restrained) (4.3%) (Fig. 4). The effect of these safety devices was indicated as the reduction in the prevalence of maxillofacial fractures. Dental injuries were not observed in patients whose airbags were deployed (Fig. 5).

In considering the impact site of the vehicle interior, we classified whether the maxillofacial fractures of the drivers were caused by impact with the steering wheel or other areas. Then we compared this proportion between the four groups. With the use of any safety device, the proportions of fractures caused by impacts with areas other than the steering were markedly decreased (52.4% to 0%). The chi-square test of association showed a global significant difference between the four groups ($p< 0.05$).

Table 1 Mean age and BMI of the patients and EBS of the involved vehicles according to use of safety devices

Seatbelt	Airbag	N	Age	BMI	EBS(km/h)
No	No	87	31.9 ±14.7	22.0 ±3.1	36.4 ±13.5
No	With	19	29.6 ±9.1	23.0 ±5.0	35.8 ±11.6
With	No	60	35.4 ±15.0	21.8 ±2.8	32.8 ±13.2
With	With	23	34.7 ±16.4	21.2 ±2.3	33.1 ±14.4

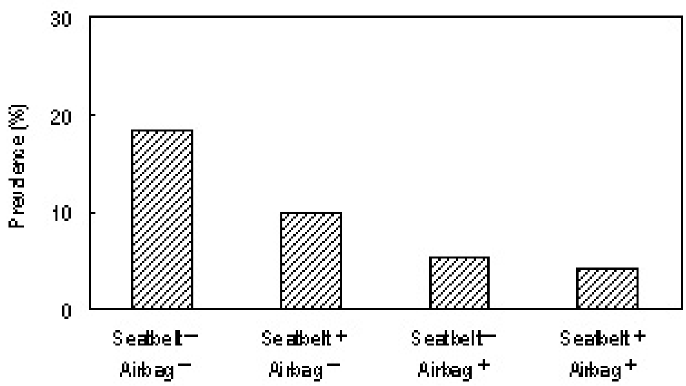

Fig. 4 Prevalence of maxillofacial fractures in drivers according to use of safety devices

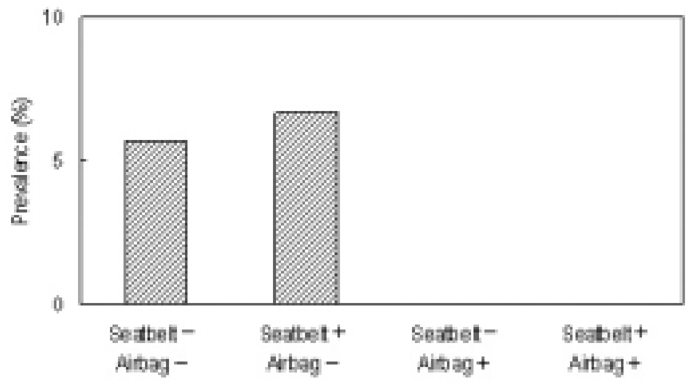

Fig. 5 Prevalence of dental injuries in drivers according to use of safety devices

Discussion

To perform an exact analysis, in addition to analyzing the patients' injuries, we examined the physical stature of the patients and the detailed collision characteristics, e.g. impact speed of the vehicle, use of safety devices. Furthermore, our consideration of the impact site that caused the maxillofacial injuries allowed a deep analysis of the injury mechanisms.

Because oral and maxillofacial injuries are seldom fatal, they are often considered minor injuries and are assigned little weight in measures of injury severity [6-8]. Therefore, the AIS-90, which defines severity as "threat to life," scores most oral and maxillofacial injuries as 1 or 2. In 89.8% of our samples, the AIS of the face was 1 and in 9.7% it was 2. Therefore, the injury severity of our cases was relatively low, with the mean AIS score of the face as small as 1.1 ± 0.3 and the mean ISS of 5.7 ± 8.3. This trend was well in accordance with previous reports that examined the anatomical injury severity of maxillofacial patients [6, 9]. Therefore, we consider that comparing maxillofacial injury severity by using an anatomical injury severity score (ISS or AIS) is difficult.

In our study, the third most common type of maxillofacial injury was fractures. Maxillofacial fractures often lead to long-term functional disabilities and esthetic complications, and they may negatively impact quality of life. Therefore, it is necessary to clarify the trends and patterns of maxillofacial fractures and to institute effective preventive measures. The most common maxillofacial fracture was to the nose, where, we think, it is fairly easy for a blunt object to impact due to the protrusion of the nose from the face. This trend was similar to the results of another previous report [10]. Furthermore, we showed that more than half of maxillofacial fractures were caused by impact with the steering. Therefore, a primary concern should be in preventing contact between the face and the steering wheel. In this study, analyses of the impact of restraint devises on maxillofacial fractures were conducted, and an impact on fracture pattern was shown.

Although the benefits of the use of seatbelts (reduction in fatality rate and injury severity) are widely accepted, in this study, some of the drivers using seatbelts also sustained maxillofacial fractures. Previously, one clinical study suggested that seatbelt use did not decrease the incidence of major maxillofacial fractures [6]. Immediately upon the start of the collision, the restrained drivers continued to move forward horizontally for a short distance until stopped by the seatbelt or by impact with the vehicle interior. In considering the impact sites in the vehicle interior, seatbelt use markedly decreased the contact between the face and objects other than the steering wheel (i.e., A-pillar, dashboard). Because some restrained drivers still sustained maxillofacial fractures due to impact with the steering wheel, we concluded that during vehicle collisions, restrained drivers are subjected to forces sufficient to cause maxillofacial fractures as their head can still be thrown against the steering wheel. However, our data confirmed that wearing a seatbelt prevents the free flight of drivers within the vehicle, as well as contact with the interior of the vehicle (other than the steering wheel).

Airbags protect motor vehicle passengers by providing a cushioning barrier between them and the vehicle interior's hard surfaces. As shown in our results, the most important effect of the airbag is to diminish the incidence of facial fractures. Furthermore, our results showed that no dental injuries were sustained in drivers with airbag deployment. This is also due to the cushioning effect of the airbag. This information could be useful for both dental surgeons and general physicians who care for the traffic collision victims.

Improving our understanding of the mechanisms of facial injuries among motor vehicle passengers can be helpful for decreasing the associated socioeconomic costs and increasing the quality of life of these patients. Although fully restrained vehicle occupants are less likely to sustain severe injuries, it may not be possible to entirely prevent maxillofacial injuries. This study may thus be useful for both maxillofacial surgeons and engineers who wish to pay greater attention to maxillofacial injuries due to motor vehicle collisions and to more effective injury protection systems.

The present research was performed at the Meeting of Multi-faced Analysis of Accidents, 2007 at ITARDA [11].

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