Maxillofacial Fractures of Pedestrians Injured in a Motor Vehicle Accident

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Abstract

Maxillofacial fractures of pedestrians injured in a motor vehicle accident were retrospectively analyzed. The patients were 38 males and 26 females, and their age was distributed almost evenly from 1 to 91 years old (average 45.9 ± 24.8 years old). Motor vehicle collisions were with an automobile in 46 patients (71.9%), a motorcycle in 17 (26.6%), and a train in 1 (1.6%). The midface was involved in 32 patients (50.0%), the mandible in 19 (29.7%), and both the mandible and the midface in 13 (20.3%). Fractures were frequently observed in the zygoma and alveolus in the midface and in the condyle, symphysis, and body in the mandible. The facial injury severity scale (FISS) rating ranged from 1 to 9 (average 2.30 ± 1.79). Injuries to other sites of the body occurred in 29 patients (45.3%). Observation was most frequently chosen in 26 patients (40.6%), followed by open reduction and internal fixation (ORIF) in 18 (28.1%), and maxillo-mandibular fixation (MMF) in 8 (12.5%). The FISS rating was higher in patients treated with ORIF and MMF. Injuries to other sites of the body were observed at a higher rate in patients who collided with an automobile and were also treated by ORIF.

Keywords

- maxillofacial fracture
- pedestrian
- motor vehicle accident

Maxillofacial fractures can have various causes, such as traffic accidents, falls, assaults, sports injuries, and others, in isolation or in combination with other injuries.^{1–11} The epidemiology of these fractures varies depending on the geographic area, socioeconomic status, and the period of investigation.^{1–11} In many countries, traffic accidents are the most common cause of maxillofacial fractures.^{1–6,10,11} The majority of patients are involved in accidents while driving an automobile or riding a motorcycle or bicycle, or as a passenger of these vehicles.^{1,2,5,6,10,11} Maxillofacial fractures of pedestrians injured in a collision with a motor vehicle are relatively rare^{1,5,10,11}; therefore, the characteristics of these fractures have not been well documented.

In the present study, we retrospectively analyzed the maxillofacial fractures of pedestrians injured in motor vehicle accidents in terms of demographics, the site and severity of

fractures, injuries to other sites of the body, and treatment modality.

Subjects and Methods

Sixty-four patients with maxillofacial fractures who were pedestrians injured in motor vehicle accidents and who were treated in the Department of Oral and Maxillofacial Surgery, Nara Medical University during the 30 years between October 1981 and September 2011 were the subjects of the present study. Patient data were obtained from their clinical records and radiographs and were retrospectively analyzed for demographics, the site and severity of the fracture, injury to other sites of the body, and treatment modality. Patients injured in an attempted suicide were excluded. The severity of maxillofacial injuries was evaluated according to the facial injury severity

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Table 1 Patient Age and Gender

Age (y)	Female	Male	Total
0–9	3	4	7
10–19	2	4	6
20–29	3	3	6
30–39	1	4	5
40–49	2	7	9
50–59	2	9	11
60–69	3	3	6
70–79	7	1	8
80–89	2	3	5
90–	1	0	1
Total	26	38	64

scale (FISS) proposed by Bagheri et al.¹² Statistical analysis was performed using the Mann-Whitney *U* test and the chi-square test. The study protocol was approved by the institutional review board and was in accordance with the principles of the Helsinki Declaration.

Results

The patients were 38 males (59.4%) and 26 females (40.6%; ► **Table 1**). The 64 patients accounted for ~ 4.8% of maxillofacial fracture patients injured in traffic accidents and 2.5% of all maxillofacial fracture patients. Thirty patients were observed in the first 10 years, 17 in the second, and 17 in the third, and accounted for 6.5%, 3.3%, and 5.3% of maxillofacial fracture patients injured in traffic accidents in the same periods, respectively. Age was distributed almost evenly from 1 to 91 years old (average 45.9 ± 24.8 years old). Eleven patients (17.2%) were in their 50s.

Injuries occurred at a slightly higher rate on Fridays in 16 patients (25.0%) and on Mondays and Sundays in 10 each (15.6% each) in terms of the day of the week, and in November in 10 patients (15.6%) and in December in 9 (14.1%) in terms of the month. Injuries occurred frequently between 15:00 and 18:00 in 13 patients (23.2%), between 18:00 and 21:00 in 11 (19.6%), and between 9:00 and 12:00 in 10 (17.9%) among the 56 patients for whom the time of the accident was recorded. Fifty-nine patients (92.2%) were referred from another clinic or hospital. The departments from which the patients had been referred were identified in 55 patients and were from emergency in 20 patients (36.4%), surgery in 13 (23.6%), and orthopedics and neurosurgery in 9 each (16.4%, each). Thirty-three patients (51.6%) visited our department within 3 days after the injury. Motor vehicles collisions were with an automobile in 46 patients (71.9%), a motorcycle in 17 (26.6%), and a train in 1 (1.6%).

The midface was involved in 32 patients (50.0%), the mandible in 19 (29.7%), and both the mandible and the midface in 13 (20.3%; ► **Table 2**). Fractures of the midface were commonly found in the zygoma in 21 patients (46.7%), followed by the alveolus in 12 (26.7%), multiple midfacial

Table 2 Details of the Fracture Site

Site of fracture	n
Midface	32
Mandible	19
Midface + mandible	13
Total	64
Fractured bone in the midface	
Zygoma	21
Maxilla	5
Multiple bones	7
Alveolus	12
Total	45
Fracture line in the mandible	
Condyle	20
Coronoid process	0
Ramus	3
Angle	4
Body	11
Symphysis	11
Alveolus	0
Total	49

bones in 7 (15.6%), and the maxilla in 5 (11.1%). In the mandible, fracture lines were single in 19 patients (59.4%), double in 9 (28.1%), and triple in 4 (12.5%). Among 49 mandibular fracture lines, 20 (40.8%) were located in the condyle, 11 (22.4%) in the body, and 11 (22.4%) in the symphysis. The severity of the maxillofacial injury was evaluated by the FISS (► **Table 3**). The FISS ratings ranged from 1 to 9 with an average of 2.30 ± 1.79 . Most injuries were not very serious. The FISS result was 1 in 33 patients (51.6%) and 2 in 9 (14.1%). The FISS rating of the patients injured by collision with a motorcycle, automobile, and train was 1.65 ± 0.93 , 2.46 ± 1.92 , and 6.00, respectively. The difference was not statistically significant.

Injuries to other sites of the body were observed in 29 patients (45.3%). Twenty-six of 46 patients (56.5%) who collided with an automobile, 2 of 17 (11.8%) with a motorcycle, and 1 of 1 (100.0%) with a train had injuries to other sites of the body. The incidence was significantly higher in automobile accidents than in motorcycle accidents ($p = 0.0014$). Injuries were most frequently observed to the head in 14 patients; followed by the chest/ribs and fibula/tibia in 7 each; and the shoulder/clavicle, arm, and femur in 6 each. The FISS rating of the patients with injuries to other sites of the body was 2.76 ± 2.08 , which was higher than the 1.91 ± 1.42 of those without such injuries, although the difference was not statistically significant.

Treatment for maxillofacial fractures is shown in ► **Table 4**. In the analysis of all patients, observation was most frequently chosen in 26 patients (40.6%), followed by open reduction and internal fixation (ORIF) in 18 (28.1%), maxillomandibular

Table 3 Site and Severity of the Injury for each cause

Cause of injury	Number of patients	Site of fracture			FISS rating		Injuries to other sites of the body (%)
		Midface	Mandible	Midface + Mandible	Range	Mean ± SD	
Collision with							
Motorcycle	17	10	5	2	1–3	1.65 ± 0.93	2 (11.8)
Automobile	46	22	13	11	1–9	2.46 ± 1.92	26 (56.5) ^a
Train	1	0	1	0	6	6.00 ± 0.00	1 (100.0)
Total	64	32	19	13	1–9	2.30 ± 1.79	29 (45.3)

Abbreviations: FISS, facial injury severity scale; SD, standard deviation.

^aSignificantly different from motorcycle ($p = 0.0014$).

fixation (MMF) in 8 (12.5%), other treatment methods in 5 (7.8%), transcutaneous reduction in 4 (6.3%), and intra-maxillary fixation in 3 (4.7%); the treatment of 13 patients with both mandibular and midface fractures was defined as more aggressive treatment for either of these sites alone. In the midface, observation was most frequently chosen in 25 patients (55.6%), followed by ORIF in 8 (17.8%). In the mandible, ORIF was frequently chosen in 15 patients (46.9%), followed by observation in 9 (28.1%), and MMF in 8 (25.0%). The FISS showed the highest value of 3.94 ± 2.13 in patients treated by ORIF, followed by 2.25 ± 0.71 in those treated by MMF. These were significantly higher than for observation ($p < 0.0001$, $p = 0.0210$, respectively). Injuries to other sites of the body were found at a significantly higher rate in patients treated by ORIF (12 of 18 patients, 66.7%) than in patients treated by MMF (1 of 8, 12.5%; $p = 0.0336$) and also at a relatively high rate in patients observed without reduction and/or fixation (15 of 26, 57.7%).

Discussion

Maxillofacial fractures are not frequently seen in pedestrians injured in motor vehicle accidents and account for less than ~ 10% of those injured in traffic accidents.^{1,5,10,11} These rates

may vary depending on road traffic conditions and the behavior of pedestrians and drivers in each area. In the present study, maxillofacial fractures of pedestrians accounted for 4.8% of those injured in all traffic accidents, a similar rate to that of another study in Japan.¹ Accidents commonly occurred with an automobile and frequently during rush hour in the morning and early evening.

The age of these patients was distributed almost evenly, with the peak age in the 50s. This result is somewhat different from the finding that maxillofacial fractures occurring by other causes are frequently observed in the young population, dominantly in males.^{13–15} This discrepancy may be partly related to the fact that the pedestrian is a victim of the accident in most cases. The ability of a pedestrian to avoid a collision with a motor vehicle, or not to be injured seriously even if involved in an accident, is quite different. Older pedestrians do not have high motor ability or reflexes due to the physiological consequences of aging and the presence of systemic pathological conditions¹⁶; therefore, they have a greater chance of being injured. On the other hand, young pedestrians have less chance of injury because of their higher ability to avoid such a hazard, although they are more active in daily life and have a greater chance of being involved in an accident.¹⁵

Table 4 Treatment according to Site and Severity of the Injury

Treatment	Number of patients	Site		FISS rating		Injury to other sites of the body (%)
		Midface	Mandible	Range	Mean $\pm$ SD	
Open reduction and internal fixation	18	8	15	1–9	3.94 $\pm$ 2.13 ^a	12 (66.7) ^b
Maxillomandibular fixation	8	0	8	1–3	2.25 $\pm$ 0.71 ^c	1 (12.5)
Intramaxillary fixation	3	3	0	1–4	2.00 $\pm$ 1.73	1 (25.0)
Transcutaneous reduction	4	4	0	1	1.00 $\pm$ 0.00	0 (0.0)
Others	5	5	0	1–6	2.00 $\pm$ 2.24	0 (0.0)
Observation	26	25	9	1–4	1.46 $\pm$ 0.90	15 (57.7)
Total	64	45	32	1–9	2.30 $\pm$ 1.79	29 (45.3)

Abbreviations: FISS, facial injury severity scale; SD, standard deviation.

^aSignificantly different from observation ($p < 0.0001$).

^bSignificantly different from maxillomandibular fixation ($p = 0.0336$).

^cSignificantly different from observation ($p = 0.0210$).

Trauma force is primarily applied to the outline of the face such as the zygoma in the midface and the body and symphysis in the mandible and causes direct fractures at the site of impact and/or indirect fracture of the condyle of the mandible. In the present study, fractures were more frequently observed in the midface than in the mandible. This result is in contrast to the findings of our previous studies that the mandible was more frequently involved in patients with maxillofacial fractures occurring by other causes.^{13–15} The reason for this inconsistency is not known. A possible explanation is that the pedestrians tried to take a defensive position by lowering their chin before colliding with a motor vehicle and/or hitting the ground. Such a position may make the midface more susceptible to injury instead of protecting the mandible. The FISS rating of maxillofacial fractures was relatively high compared with those injured by other causes.^{13–15} Fractures involving both the midface and the mandible, multiple bone fractures in the midface, and double and triple fracture lines in the mandible are responsible for the high FISS rating. This is because the fractures occurred as a result of high-velocity impact in motor vehicle collisions and when hitting the ground as a result of these collisions.

Injuries to other sites of the body were observed in 45.3% of the patients, higher than in those injured by other causes.^{13–15} This result is as expected because pedestrians often suffer from multiple and serious injuries to the body in a collision with a motor vehicle. The rate was significantly higher in accidents with an automobile than in those with a motorcycle (56.5% versus 11.8%, $p = 0.0014$), probably because of the impact with higher velocity force. Fractures to lower extremities are commonly observed due to hitting the bumper of an automobile.^{17,18} Injuries to the head, shoulder/clavicle, and chest/ribs are also observed frequently.^{19,20} These patients often need to be primarily treated in other medical departments, and therefore their maxillofacial fractures are untreated before referral to our department.²⁰ Only half of the patients were referred to our department within 3 days after the injury. Although collision with a motor vehicle is sometimes fatal, no death was recorded in the present study. This result is considered partly due to the underestimation of mortality rates in studies of oral and maxillofacial surgery, because patients with fatal injuries may die at the scene or soon after arrival and never reach maxillofacial surgeons.²¹ In pedestrians who collide with an automobile, age plays a critical role in the anatomic distribution and severity of injuries.^{18,22} Older victims are significantly more likely to suffer severe injuries, especially to the head and chest.²² In the present study, injuries to other sites of the body were observed at a higher rate in patients 65 years old and older than in patients younger than 65 years old (10 of 16 patients, 62.5% versus 19 of 48 patients, 39.5%), although it was not statistically significant; however, FISS ratings in patients 65 years old and older were similar to that in patients younger than 65 years old (2.38 ± 1.63 , versus 2.29 ± 1.88). These results suggest that maxillofacial fractures in pedestrians injured in a motor vehicle accident are generally associated injuries rather than those affecting the survival outcome of the patients.

Treatment was chosen according to the condition of the patients. ORIF was performed in less than 30% of patients. Observation was chosen for ~ 40% of patients and more frequently for fractures of the midface (25 of 45 patients, 55.6%) than those of the mandible (9 of 32 patients, 28.1%). This is partly because aggressive treatment is not chosen for a slight facial deformity in the midface unless function is so impaired, especially for patients with injuries to other sites of the body.¹⁶ MMF was exclusively performed for mandibular fractures, and intramaxillary fixation, transcutaneous reduction, and others were primarily used for midface fractures, consistent with our previous studies.^{15,16} FISS rating was highest in patients treated by ORIF, followed by those treated by MMF, both of which were significantly higher than with observation. These results indicate that severe fractures with higher FISS ratings needed to be treated aggressively.^{13–15} The rate of injuries to other sites of the body in patients treated by ORIF (66.7%) was significantly higher. This result reflects the fact that patients with injuries to other sites of the body showed higher FISS ratings than those without such injuries (2.76 ± 2.08 versus 1.91 ± 1.42), although the difference was not statistically significant. Interestingly, the rate of injuries to other sites of the body was also relatively high in patients observed without reduction and/or fixation. This result may indicate that maxillofacial fractures in patients with such injuries sometimes need to be observed, if not so serious, primarily to treat the injuries to other sites of the body.^{13,16}

In conclusion, maxillofacial fractures of pedestrians injured in motor vehicle accidents showed characteristic features different from those injured by other causes in terms of the demographics, site, and severity. An understanding of these features will greatly help to promote clinical research to develop more effective management and possibly to prevent injury.

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