Epidemiology of Maxillofacial Injuries at Trauma Hospitals in Ontario, Canada, Between 1992 and 1997

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Background: **The purpose of this study was to review the epidemiology of maxillofacial skeletal injuries in severely injured patients admitted to trauma hospitals in Ontario, Canada, with an Injury Severity Score > 12.**

Methods: **The Ontario Trauma Registry was accessed to examine the epidemiology of maxillofacial skeletal injuries in severely injured patients treated at 12 trauma hospitals in the province of Ontario, Canada, between 1992 and 1997. Data were collected prospectively, and a descriptive analysis was performed to determine the pattern of maxillofacial injuries, including patient age, sex distribution, etiology of injury, time of injury, and injury profile.**

Results: **There were 2,969 patients that met the inclusion criteria. The median age was 25 years, and men were injured at a 3:1 ratio over women. Most severely injured patients with maxillofacial fractures were injured as a result of motor vehicle collision (70%), with only 33% of the patients restrained with a seatbelt. The temporal distribution of injuries showed that most injuries occurred during evening hours, on weekends, and in the summer. The largest number of fractures was found in the maxilla and orbital bones. The Injury Severity Score of the patients in this study ranged from 13 to 75, with a median of 25. The injury most commonly associated with maxillofacial fractures was injury to the head and neck area. Of patients with injury to the head and neck, most had an altered level of consciousness or injuries to the skull, brain, or cranial vessels.**

Conclusion: **Many severely injured patients have maxillofacial injuries. Long-term collection of epidemiologic data regarding maxillofacial fractures is important for the evaluation of existing preventative measures and useful in the development of new methods of injury prevention. Furthermore, insight into the epidemiology of facial fractures and concomitant injuries is an integral component in evaluating the quality of patient care, developing optimal treatment regimens, and making decisions regarding appropriate resource and manpower allocations.**

Key Words: **Maxillofacial injuries, Injury, Epidemiology, Trauma**

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Maxillofacial injuries occur in a significant proportion of trauma patients. They can occur in isolation or in combination with other serious injuries, including cranial, orthopedic, and cervical spine injuries.[1,2] The epidemiology of facial fractures varies in injury type, severity, and cause depending on the population studied.[2,3]

Many early studies have shown motor vehicle collisions (MVCs) to be an important cause of maxillofacial fractures.[4–11] Recent international studies have confirmed that MVCs are still the primary cause of facial trauma.[1,3,12] Because of legislative changes and preventative measures involving seatbelt and airbag use, as well as the reduction of drinking and driving, MVC-related facial injuries have decreased in some developed countries, and assaults and falls have emerged as the predominate mechanisms of facial trauma.[2,3,13–16] The differences between populations in the causes of maxillofacial fractures may be the result of cultural and risk factor differences between countries but are more likely influenced by the levels of injury severity used as selection criteria for the epidemiologic investigations.

An understanding of the cause, severity, and temporal distribution of maxillofacial trauma can aid in establishing clinical and research priorities for effective treatment and prevention of these injuries. Continuous long-term collection of data regarding the epidemiology of maxillofacial fractures is important because it provides information necessary for the development and evaluation of preventative measures for reducing the incidence of facial injuries.[2,13] Prospective data collection requires an investment in an appropriate infrastructure that provides accurate detailed recording capabilities as well as analysis of data on a regular basis. The Ontario Trauma Registry (OTR) was established in 1992 for this purpose. Its goal is to facilitate the reduction of injury in Ontario by identifying, describing, and quantifying trauma for use in the planning and evaluation of preventative programs, as well as legislative changes and cost expenditure estimates.[17]

A descriptive profile of the types and causes of maxillofacial trauma for the Canadian population, and specifically Ontario, does not exist. Although these data are available for areas in other countries, including the United States and England, age distribution, socioeconomic and cultural differences, and differential exposure to injury risk factors contrib-

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ute to variation between countries.[3,18] The purpose of this study was to provide an epidemiologic description of maxillofacial injuries in patients with severe or multiple injuries (Injury Severity Score [ISS] > 12) treated at trauma hospitals in Ontario between 1992 and 1997.

MATERIALS AND METHODS

The study population consisted of 2,969 severely injured patients with maxillofacial fractures treated at 12 trauma hospitals in the province of Ontario, Canada, from January 1, 1992, to December 31, 1997. The 12 hospitals were responsible for the collection and submission of data into the Comprehensive Data Set of the OTR[19] for patients with severe or multiple injuries with ISS > 12. Of the 12 hospitals, 10 were officially designated lead trauma hospitals by the Ontario Ministry of Health in 1991. Two additional hospitals, although not formally designated or funded by the government, were committed to trauma care and therefore participated in the collection and submission of data to the OTR.

Detailed data were collected prospectively for each patient with severe or multiple injuries with ISS > 12[20] and DRG International Classification of Disease—9th Rev.—Clinical Modification (ICD-9-CM) external cause of injury codes satisfying the OTR definition of trauma.[21,22] Each patient file contained detailed demographic, injury, and treatment information from the injury scene and prehospital care through the entire acute care hospital visit. Information was recorded on each patient's age, sex, blood alcohol concentration (BAC), types of maxillofacial injuries, ISS, concomitant injuries, and cause, place, and time of injury. All injuries in all body regions were recorded, and severity was scored and entered into the Comprehensive Data Set.

All patients treated at the trauma hospitals were assigned an ISS calculated using the method designed by Baker et al.[20] The ISS, a valid numerical classification of the overall severity of injury in persons who have sustained multiple injuries, uses a combination of the severity of injuries in the three most severely injured body regions to quantify the extent of trauma.[20] Because the OTR Comprehensive Data Set used in this study was restricted to patients with ISS > 12, the descriptive analysis presented was limited to patients with severe or multiple injuries who had one or more maxillofacial injuries of the maxilla, mandible, alveolar ridge, nasal bones, bones in the orbital region, zygoma, teeth, or temporomandibular joint.

Before statistical analysis, data were checked to ensure quality. This process involved using other data available in the patient's trauma record or contacting the OTR to receive additional clarification from the treating institution for missing or erroneous data. The Pearson χ^2 test was used to test for a difference in the population proportions between groups of patients. Logistic regression was used to determine the odds ratio (OR) and 95% confidence interval for the effect of airbag deployment on odds of maxillofacial injury in all severely injured patients while controlling for potential confounders. After fitting the model, the OR was defined as the odds of maxillofacial injury among exposed (airbag deployed crashes) relative to the odds of maxillofacial injury among nonexposed (no airbag deployment) adjusted for age, sex, seatbelt use, frontal crash involvement, and ejection status. All statistical analysis were performed using COLLECTOR trauma registry software (Tri-Analytics, Inc., Bel Air, MD) and SAS statistical software (SAS Institute, Inc, Cary, NC).

RESULTS

From 1992 to 1997, 17% (n = 2,969) of 17,328 patients treated at 1 of the 12 trauma hospitals in Ontario with ISS > 12 had maxillofacial injuries. An injury profile of all 17,328 severely injured patients in the Comprehensive Data Set compared with those with maxillofacial injuries is presented in Table 1.

Age and Sex Distribution

The age of patients at the time of injury ranged from 1 to 99 years of age with a median age of 25 years (Figure 1). A greater proportion of severely injured patients with facial

Table 1. Selected Characteristics For All Severely Injured Trauma Patients (ISS > 12) and Maxillofacial Patients in the Ontario Trauma Registry's Comprehensive Data Set, 1992–97

Descriptive Statistic	All Patients (ISS > 12) n (%)	Maxillofacial Patients (ISS > 12) n (%)
Total patients	17,328	2,969
Sex		
Male	12,296 (71)	2,208 (74)
Female	5,030 (29)	761 (26)
Not given	2 (0)	—
Type of admission		
Transfer	9,519 (55)	1,636 (55)
Direct	7,809 (45)	1,333 (45)
Discharge status		
Alive	14,733 (85)	2,594 (87)
Death	2,595 (15)	375 (13)
Time to death		
<24 h	1,171 (45)	171 (46)
≥24 h	1,317 (51)	191 (51)
Unknown	107 (4)	13 (4)
Injury type		
Blunt	16,123 (93)	2,876 (97)
Penetrating	929 (5)	93 (3)
Burn	276 (2)	—
Etiology		
MVC	9,650 (56)	2,064 (70)
Falls	4,030 (23)	344 (12)
Homicide/assault	1,199 (7)	234 (8)
Suicide/self inflicted	541 (3)	78 (3)
Other	1,908 (11)	249 (8)
Age (yr)		
Median (range)	36 (0–100)	33 (1–99)
ISS		
Median (range)	24 (13–75)	25 (13–75)

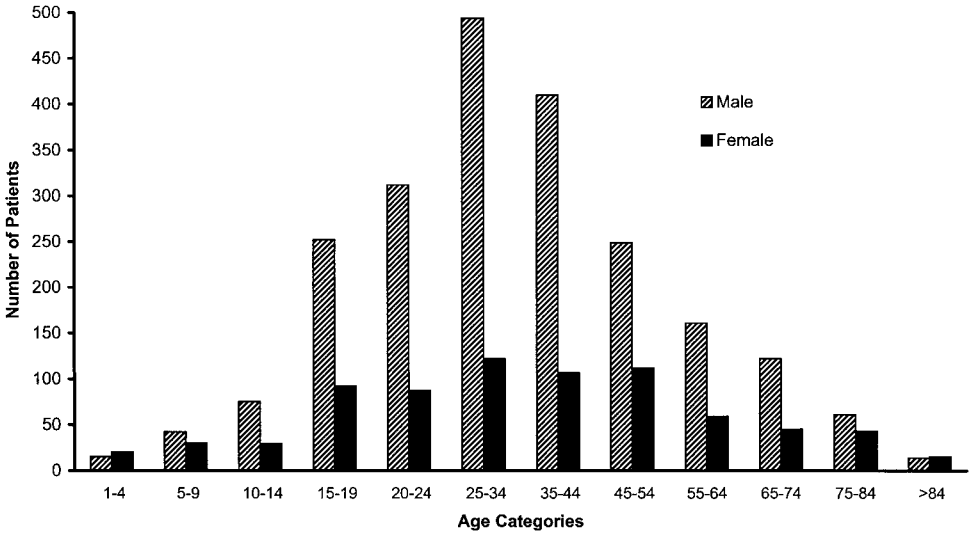

Fig. 1. *The age and sex distribution at the time of injury of the 2,969 patients with maxillofacial injury treated at trauma hospitals in Ontario, Canada, from 1992 to 1997.*

injuries were men (n = 2,208) compared with women (n = 761), resulting in a ratio of nearly 3:1. Men between 25 and 34 years of age were the most frequently injured cohort, comprising 17% (n = 494) of the study population.

Etiology and Restraint Use

The most common cause of injury was MVC (70%, n = 2,064). Only 33% of patients that sustained a maxillofacial injury were wearing a seatbelt. A lack of seatbelt resulted in a significantly higher proportion of facial trauma patients with concomitant injuries to the head and neck (89% vs. 79%, $p < 0.001$) and skin (61% vs. 56%, $p < 0.05$) and fewer abdominal injuries (26% vs. 31%, $p < 0.05$) compared with patients restrained by a seatbelt. In addition, patients not wearing a seatbelt had a statistically higher median ISS (27 vs. 24, $p < 0.001$). Of the patients with maxillofacial injury, only 28 were involved in a crash in which the airbag deployed. There were no statistical differences in the associated injury profile or ISS in these patients. For all severely injured patients (ISS > 12) in the Comprehensive Data Set, the odds of sustaining a maxillofacial injury with airbag deployment was significantly lower (OR = 0.564, 95% CI 0.371, 0.856), even after controlling for the confounding effects of age, sex, seatbelt use, frontal crash involvement, and ejection status.

Other common causes of maxillofacial trauma were falls and intentional injury (Table 1). The leading place of injury corresponded with the mechanisms, with 69% (n = 2,058) of maxillofacial traumas injured on a street or highway and 10% (n = 295) injured at home. There were 204 patients (7%) with work-related facial injuries. Of patients providing information about their occupations, 30% (n = 45) were employed in construction trades.

Penetrating injuries accounted for 3% (n = 93) of all injuries; of these, 72% (n = 67) were gunshot wounds and 15% (n = 14) were stabbing wounds. Many patients had a positive BAC during injury (26%, n = 784). Of these patients, 85% (n = 668) were men and most were between 25 and 34 years of age (29%, n = 195). As with all cases of maxillofacial trauma, most patients with positive BAC were injured by MVCs (68%), followed by intentional injury (15%).

Time of Injury

One quarter of the patients suffering facial trauma were injured between 2:00 PM and 7:00 PM (25%, n = 732), whereas fewer patients were injured between 3:00 AM and 8:00 AM (11%, n = 315) (Figure 2). The weekly profile of injuries showed that more than half of patients were injured on the weekend, including Friday (51%, n = 1,507). The monthly distribution of the occurrence of injuries is shown in Figure 3. The lowest number of patients were injured during February (n = 177), and the monthly totals increased from April through the spring and summer months, peaking in August, when 331 patients were injured. Both the absolute number and the proportion of maxillofacial injuries peaked in 1995 (Table 2).

Injury Profile

There were a total of 5,826 individually coded maxillofacial injuries in the 2,969 patients in the study population. If a patient sustained multiple injures to the face, all injuries, from the least minor to the most severe, were entered separately. The maxilla and orbital regions had the largest proportion of fractures (23% and 22%, respectively) (Figure 4). The ISS of patients ranged from 13 to 75 with a median ISS of 25. The majority of patients injured had an ISS between 16 and 40 (75%, n = 2225). Head and neck injuries were the most common injuries associated with maxillofacial fractures (87%, n = 2,595) (Figure 5). Of patients with injuries in the head and neck area, 98% (n = 2,556) had an injury to the

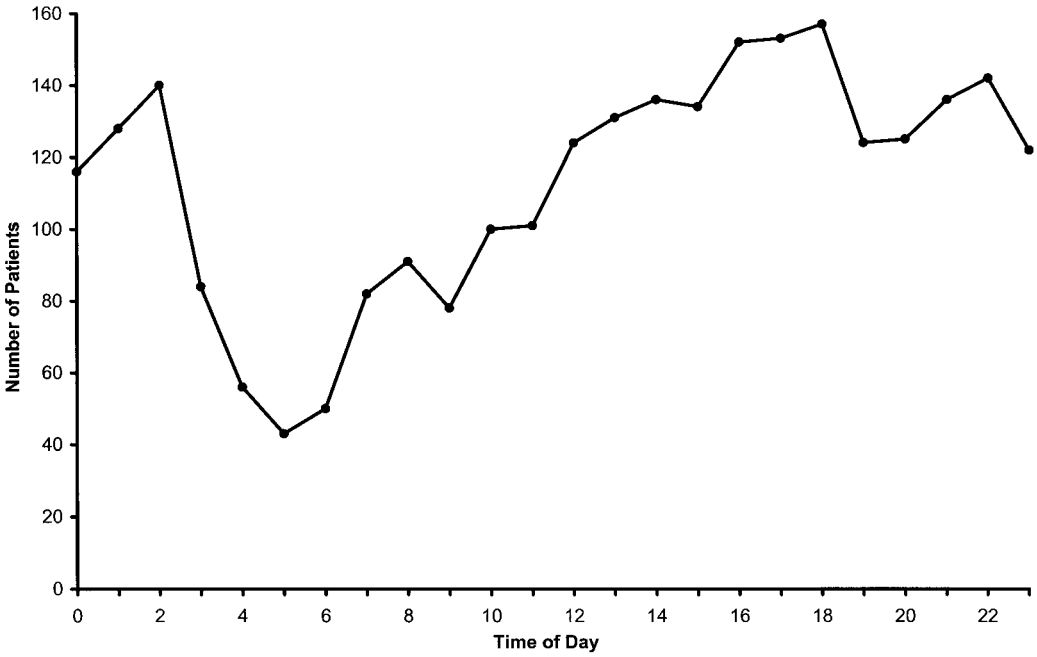

Fig. 2. *The time of injury occurrence for the 2,969 patients with maxillofacial injury treated at trauma hospitals in Ontario, Canada, from 1992 to 1997.*

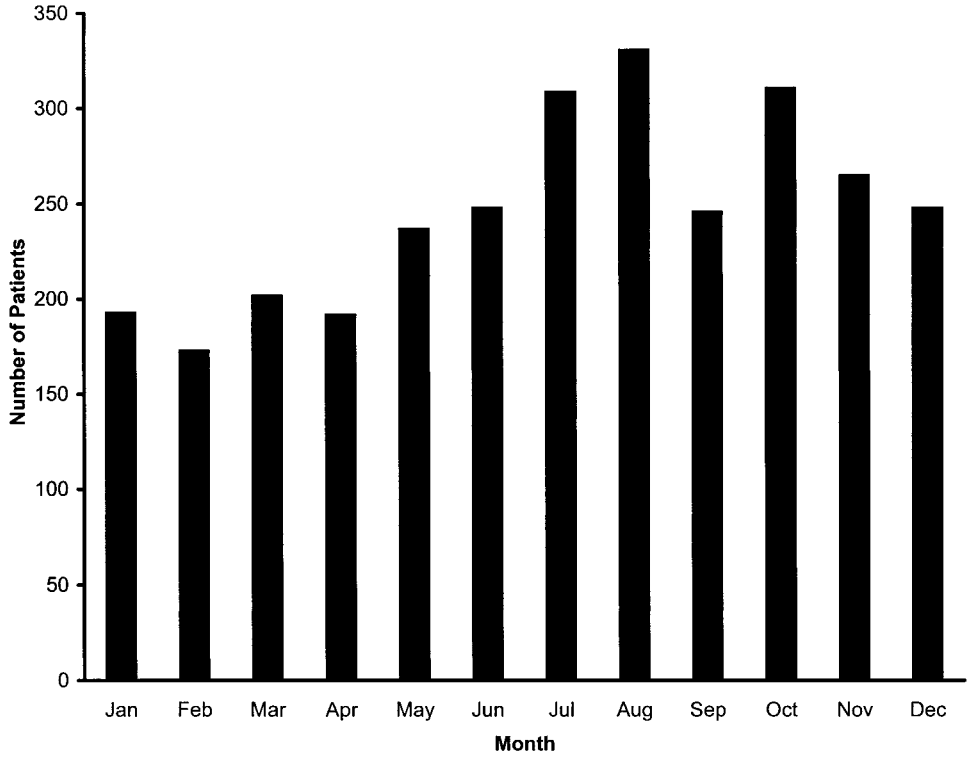

Fig. 3. *The monthly distribution of injury of the 2,969 patients with maxillofacial injury treated at trauma hospitals in Ontario, Canada, from 1992 to 1997.*

Table 2. Number and Proportion of Maxillofacial Trauma Patients Compared With Total Cases With ISS > 12 in the Ontario Trauma Registry's Comprehensive Data Set, 1992-97

Year	All Patients (ISS > 12)	Maxillofacial Patients (ISS > 12)	% of Total
1992	2,450	421	17.2
1993	2,795	490	17.5
1994	2,851	511	17.9
1995	3,028	558	18.4
1996	3,073	514	16.7
1997	3,131	475	15.2
Total	17,328	2,969	17.1

skull, brain, or cranial blood vessels or an altered level of consciousness, 11% (n = 279) had a cervical spine injury, and 2% (n = 45) had an injury of the soft tissue of the neck.

DISCUSSION

The results of epidemiologic investigations vary depending on the demographics of the population studied. Factors such as geographic region, socioeconomic status, and temporal factors including time of year and era can influence both the type and frequency of injuries in the population.[2] This makes meaningful comparisons between epidemiological reviews difficult. The present study was conducted using a database collected in 12 trauma hospitals in Ontario, Canada, during the period from 1992 to 1997. Only patients with ISS > 12 were included in the database.

Severely injured patients often have injuries in the maxillofacial region, ranging from small lacerations to multiple fractures of facial bones. Estimates of the incidence of facial fractures in patients with multiple injuries with ISS ≥ 16 ranged from 15% to 22%.[1,23,24] These estimates are consistent with the situation in Ontario, where 17% of severely injured patients admitted to the provincial trauma hospitals have maxillofacial fractures. Although many studies have examined the epidemiology of isolated mandibular, maxillary, or zygomatic fractures, fewer general reviews exist of the incidence of all maxillofacial fractures in severely injured patients.[1]

This is the first comprehensive profile of significant maxillofacial injury in Canada. Our results found that despite the increased use and design of protective devices for motor vehicle occupants, MVCs remain the leading cause of injury. Historically, this has been consistently reported in other international investigations.[3–12] Etiology is an influential factor in the severity of injuries that result from trauma.[15] The large amounts of energy transferred from all stages of a crash, from an object to the vehicle, from the vehicle to the body, and finally from organs and vessels colliding within the body itself, can result in multiple, severe injuries. This has been demonstrated by studies in the United States and England, which have found MVCs to be the most common cause of maxillofacial injury in patients that have serious or multiple injuries.[1] In Ontario, despite a primary seatbelt law being in effect since 1976 and Ministry of Transportation data that demonstrate an 88% seatbelt usage rate in collisions,[25] only

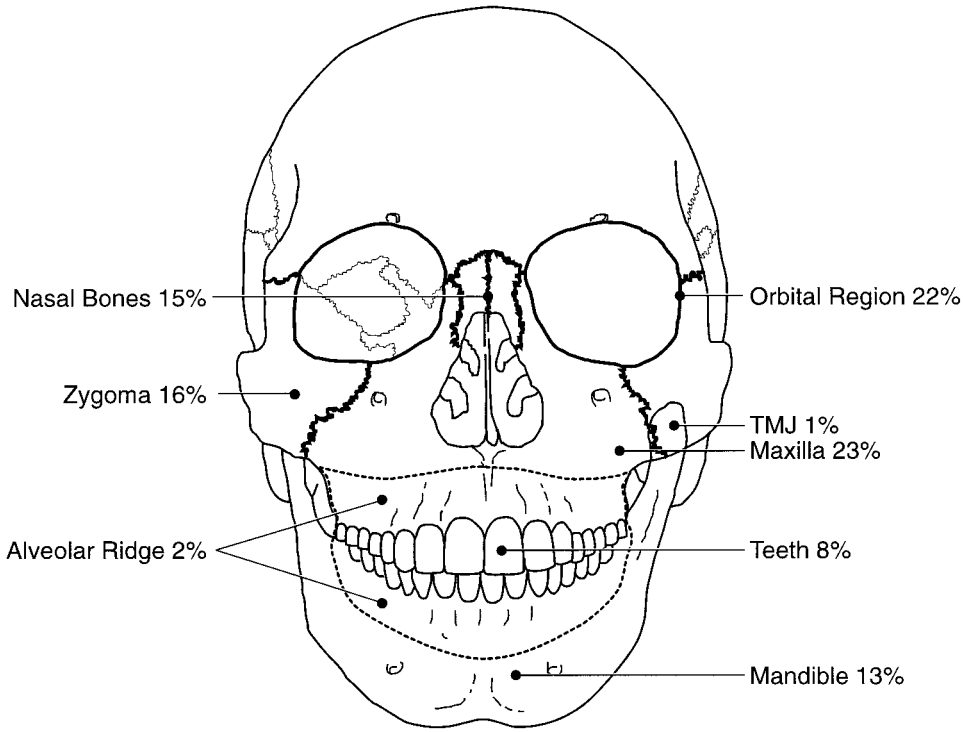

Fig. 4. *The skeletal region of maxillofacial injury in the 2,969 patients treated at trauma hospitals in Ontario, Canada, from 1992 to 1997.*

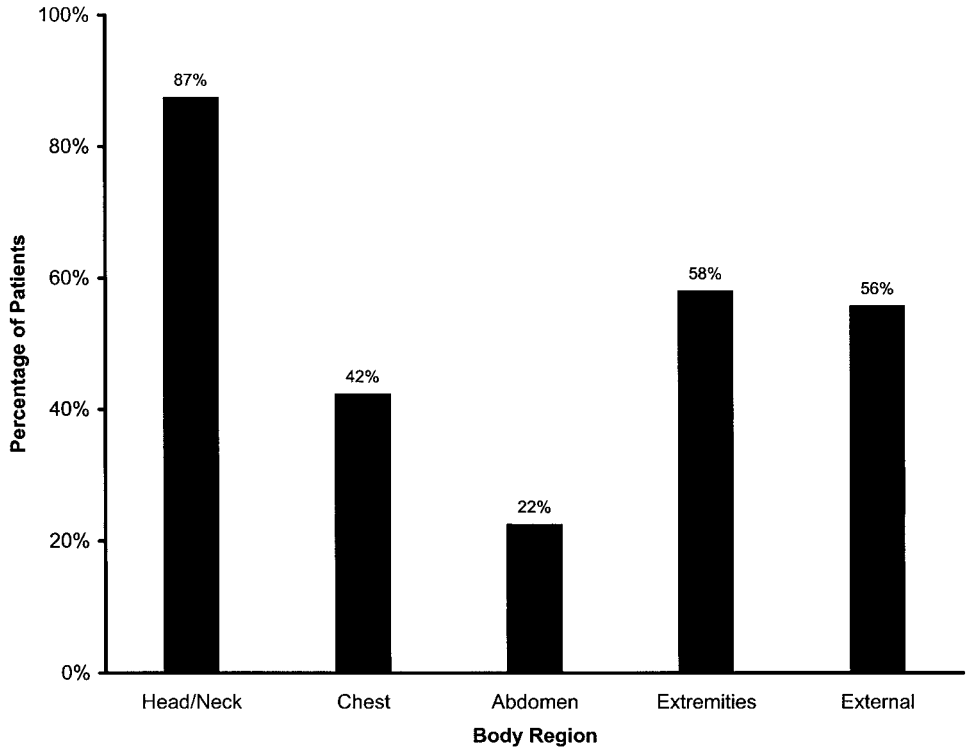

Fig. 5. *Associated injury profile for the 2,969 patients with maxillofacial trauma treated at trauma hospitals in Ontario, Canada, from 1992 to 1997.*

33% of the maxillofacial trauma patients were restrained with a seatbelt. This demonstrates that nonrestrained occupants are injured in crashes at a rate more than five times the rate of those wearing a seatbelt. These crashes resulted in more patients with multiple injuries with a significantly higher proportion of head, neck, abdominal, and skin injuries.

In our study population, interpersonal violence did not constitute as large a proportion of injuries as in previous studies,[13,26,27] nor did it have as large of a proportion of nasal fractures as a study in London, England.[16] This may result from inclusion criteria for this analysis being restricted to patients with severe or multiple injuries, thereby excluding any patients with isolated injuries to single bones of the face, such as nasal fractures, that may result from minor assaults.

In the present study, the most commonly fractured bones were the maxilla and orbit. The high number of concomitant injuries in this study was also a result of the inclusion criteria. The most common associated injuries were in the area of the head and neck. These included cranial fractures, brain injury, altered levels of consciousness, large lacerations on the neck, and cervical spine injuries. Other studies have shown an association between concomitant injuries and maxillofacial fractures in severely injured patients.[2,28–30]

In our study, the largest number of injuries occurred between 2:00 PM and 7:00 PM. This may be a consequence of the high incidence of MVCs. It is common for vehicles to be on the road between 2:00 PM and 7:00 PM, commuting home from work or picking up children from school. The end of this range is also the time, particularly in the winter months, when daylight diminishes and potentially causes visibility problems on the roadways. Additional temporal data show that the majority of maxillofacial injuries in Ontario occurred on the weekends in the summer months, supporting the finding of previous facial studies.[31,32]

The decrease in the proportion of maxillofacial injuries in the total severely injured Ontario population in the last 2 years of study has been influenced by the latest motor vehicle occupant protective technology, the airbag. In this population, 70% of the injuries were the result of an MVC. The purpose of an airbag is to decrease head, cervical spine, and facial injuries by providing a cushioning effect to allow for more controlled deceleration of the head and to prevent contact with the steering wheel and windshield.[33] For all severe MVCs involving patients with ISS > 12, air bag deployments increased each year from 6 (0.4%) in 1992 to 76 (4.7%) in 1997. This has resulted in lowering the proportion of facial injuries, particularly in years 1996 and 1997, which have the highest proportion of airbag deployments (3% and 5%, respectively). Our results demonstrate that the odds of maxillofacial injury is nearly cut in half by the deployment of an airbag (adjusted OR $= 0.564$, 95% CI 0.371, 0.856).

Although additional investigation into airbag deployment and whether the vehicles involved in these crashes were equipped with this technology would be important, these data were not available in the Comprehensive Data Set. This is an inherent limitation of retrospective data analyses.

In general, trauma is primarily a health problem of young men. This is not different for severe maxillofacial trauma in Ontario, in which the most frequently injured group was men between 25 and 34 years of age. The large number of men injured in this study is consistent with previous reports.[2,3,5–8,23,34] Our male:female ratio was similar to the 3:1 ratio found by Bataineh[3] in Jordan but lower than the 5:1 ratio in the European study by Van Hoof et al.[4]

Many severely injured patients have maxillofacial fractures. Long-term collection and analysis of epidemiologic data regarding maxillofacial fractures in severely injured patients is an important step in the evaluation of conventional preventative measures. It is also necessary to determine trends to help guide the development of new methods of injury prevention. From our results, it is evident that more prevention initiatives are needed to decrease the trauma from MVCs, because the majority of severe maxillofacial injuries occur in these crashes. The advent of driver- and passenger-side airbags, as well as side-impact airbags, is a positive step in this direction. This study demonstrated the protective effect of airbags, and more vehicles equipped with airbags should result in fewer maxillofacial injuries. Violence prevention programs concentrating on both assault and self-inflicted injury may help decrease the maxillofacial trauma resulting from intentional injuries in this population. In addition to the current drinking and driving campaigns, a specific component on controlling alcohol use is needed for both MVC and violence prevention programs, because $>$ 80% of the alcohol-related injures involved these two mechanisms.

Insight into the epidemiology of facial fractures and associated injuries is useful not only in prevention strategies, but also in decision making for patient care, development of optimal treatment regimens, and appropriate resource allocation. Facial fractures commonly occur in combination with other serious head and spinal injuries. Their diagnosis and treatment have the potential to be overlooked or delayed in these severely injured patients. Future studies to assess this should include an evaluation of the timing of fixation of facial fractures that occur in isolation and combination with other injuries and the resulting effect on treatment and patient outcomes.

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