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Cranio-maxillofacial trauma: a 10 year review of 9543 cases with 21 067 injuries

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SUMMARY. Introduction: **Cranio-maxillofacial trauma management requires pertinent documentation. Using a large computerized database, injury surveillance and research data describe the whole spectrum of injuries. The goal of this study was to assess the effect of the five main causes of accidents resulting in facial injury on the severity of cranio-maxillofacial trauma.** Patients and Methods: **During a period of 10 years (1991–2000) 9543 patients were admitted to the Department of Oral and Maxillofacial Surgery, University Hospital of Innsbruck with cranio-maxillofacial trauma. Data of patients were prospectively recorded including cause of injury, age and gender, type of injury, injury mechanisms, location and frequency of soft tissue injuries, dentoalveolar trauma, facial bone fractures and concomitant injuries. Statistical analyses performed included descriptive analysis, chi square test, Fisher's exact test, and Mann–Whitney's U test. This was followed by logistic regression analyses for the three injury types to determine the impact of the five main causes on the type of injury at different ages in facial trauma patients.** Results: **Five major categories/mechanisms of injury existed: in 3613 (38%) cases it was activity of daily life, in 2991 (31%) sports, 1170 (12%) violence, in 1116 (12%) traffic accidents, in 504 (5%) work accidents and in 149 (2%) other causes. A total of 3578 patients (37.5%) had 7061 facial bone fractures, 4763 patients (49.9%) suffered from 6237 dentoalveolar, and 5968 patients (62.5%) from 7769 soft tissue injuries. Gender distribution showed an overall male-to-female ratio of 2.1 to 1 and the mean age was 25.8 ± 19.9 years; but both varied greatly depending on the injury mechanism (facial bone fractures: 35.4 ± 19.5 years, higher risk for males; soft tissue injuries: 28.7 ± 20.5, no gender preference; dentoalveolar trauma: 18 ± 15.6, elevated risk for females). For patients sustaining facial trauma, logistic regression analyses revealed increased risks for facial bone fractures (225%), soft tissue lesions (58%) in patients involved in traffic accidents, and dental trauma (49%) during activities of daily life and play accidents. When compared with other causes, the probability of suffering soft tissue injuries and dental trauma, but not facial bone fractures, is higher in sports-related accidents, 12 and 16%, respectively.** Conclusion: **This study differentiated between injury mechanisms in cranio-maxillofacial trauma. The specially trained surgeons treating cranio-maxillofacial trauma are the primary source of information for the public and legislators on implementing preventive measures for high-risk activities. In facial trauma, older persons are prone to bone fractures (increase of 4.4%/year of age) and soft tissue injuries (increase of 2%/year of age) while younger persons are more susceptible to dentoalveolar trauma (decrease of 4.5%/year of age).** © **2002 European Association for Cranio-Maxillofacial Surgery.**

INTRODUCTION

The management of cranio-maxillofacial trauma includes treatment of facial bone fractures, dentoalveolar trauma, and soft tissue injuries, as well as associated injuries, mainly of the head and neck (*Hausamen*, 2001). In the established hospital concept of 24-hour-trauma-service documentation of individual cases leads to the accumulation of large amounts of patient data over the years. The impact of the driving factors on direct and indirect costs of the sequelae of trauma therapy, as well as the epidemiology of facial trauma, need to be allocated to their cause (*Hogg* et al., 2000). Additionally, the success of treatment and implementation of preventive measures are more specifically dependent on epidemiological assessments (*Mouzakes* et al., 2001).

Cranio-maxillofacial injuries affect a significant proportion of trauma patients. They can occur in isolation, or in combination with other serious injuries, including cranial, spinal, upper and lower body injuries (*Hussain* et al., 1994; *Oikarinen*, 1995). The epidemiology of facial fractures varies in type, severity, and cause depending on the population studied (*Haug* et al., 1990; *Girotto* et al., 2001). The differences between populations in the causes of maxillofacial fractures may be the result of risk factors and cultural differences between countries but are more likely to be influenced by the injury severity.

An understanding of the cause, severity, and temporal distribution of maxillofacial trauma can assist in establishing clinical and research priorities for effective treatment and prevention of these injuries. Continuous long-term data collection on maxillofacial fractures is important because it allows the development and evaluation of preventative measures (*Hogg* et al., 2000). Prospective and retrospective data collection allows accurate detailed recording as well as regular data analysis. The Oral and Maxillofacial Trauma Registry at the University of Innsbruck, Austria was created in 1991 for this purpose. Its goal was to facilitate the awareness of injury, especially cranio-maxillofacial injury, in the Alps by identifying, describing, and quantifying trauma for use in planning and evaluation of preventative programmes, as well as legislative changes and cost/expenditure estimates.

Injury surveillance and research data at this centre reflect the whole spectrum of cranio-maxillofacial injuries; five main causes of injury were identified, namely work, traffic, assaults, sports and activities of daily life (ADL) (*Gassner* et al., 1999a–c).

Our goals were to enlarge facial trauma by evaluating data on patients with facial bone fractures, dentoalveolar trauma and soft tissue injuries, and to investigate the impact of the five main causes of facial injury. Furthermore, this study assesses the statistical patterns of cranio-maxillofacial trauma in relation to accident causes including the use of logistic regression analyses.

PATIENTS AND METHODS

During the decade of January 1, 1991 to December 31, 2000, 9543 patients with cranio-maxillofacial trauma were registered at the Department of Oral and Maxillofacial Surgery in the University Hospital of Innsbruck. Data were collected including medical history, patient's symptoms, clinical signs and the radiological findings.

Frequency and type of injury (facial bone fractures, dentoalveolar trauma and soft tissue injuries), as well as age and gender distribution, monthly and yearly distribution, nationality of patients, cause of accidents and concomitant injuries were analysed. Comparisons were performed with chi^2 tests, Fisher's exact tests, and Mann–Whitney's U tests, as appropriate. This was followed by logistic regression analyses for the three injury types to determine the impact of the five main causes of cranio-maxillofacial injury. The final regression model included the variables age, gender, and type of facial trauma. Odds ratios and their 95% confidence intervals were calculated to represent the relative risk of: age, gender, ADL (activities of daily life), play, sports, traffic, violence, and work-related accident.

RESULTS

Altogether at total of 9543 patients sustained 21 067 cranio-maxillofacial injuries. Activities of daily life (ADL) and play accidents (3613) caused the majority of injuries (38%), followed by 2991 sports injuries (31%), 1170 assaults (12%), 1116 traffic accidents (12%), and 504 work-related accidents (5%). Less than 1.6% of all accidents (1 4 9) were due to other causes (Fig. 1). The main causes of sport accidents were skiing (950 patients, 31.8%), bicycling (707 patients, 23.6%) and soccer (240 patients, 8.6%). Forty-four other sports were cited.

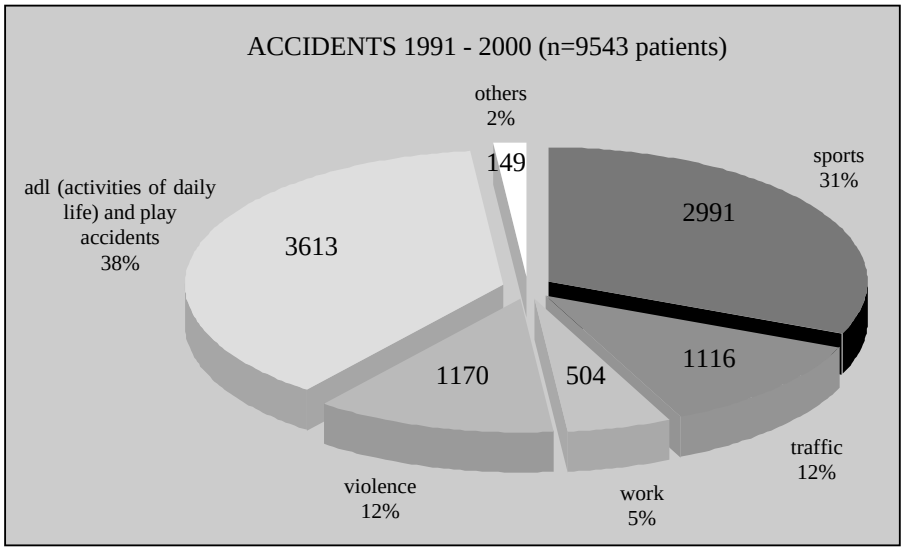

Fig. 1 – Cranio-maxillofacial trauma 1991–2000.

Age distribution

The age of patients at time of injury ranged from 1 to 99 years, with a median of 22 and a mean of 25.8. Ten percent of the patients were less than 5 years old, 50% were between 10 and 37 years, and 30% were between 38 and 54 years, while 10% were older than 55 years (Table 1).

The overall age distribution of the 9543 patients showed decreasing rates of accidents every decade of life (as presented in Fig. 2) except in the first three decades of life. In the first decade, 4016 injuries (19.1%) occurred; 4020 (19.1%) during the second, 4660 (22.1%) in the third, 3063 (14.5%) in the fourth, 1996 (9.6%) in the fifth, 1415 (6.7%) in the sixth, 874 (4.1%) in the seventh, 615 (2.9%) in the eighth, 357 (1.7%) in the ninth, and 51 (0.2%) in the tenth. Of all injuries, 60.3% occurred in the first three decades of life.

Regarding age, Fig. 2 illustrates the breakdown. Play accidents dominated in the first decade of life. The occurrence of sports injuries peaked in the second and third decade, and were still the most common cause of trauma in the fourth and fifth decades. Yet, the frequency of sports injuries decreased as the patient's ages increased, whereas the rate of accidents from ADL rose with ages, becoming the prevailing cause from the sixth to the tenth decade. Violence (assault), work, and traffic accidents were most prevalent in the third decade of life (Fig. 2).

Age-related differences existed for male and female patients, between the types of injury. The mean age of patients suffering from dentoalveolar trauma was 18 ± 15.6 years, compared with patients having soft tissue injuries, (28.7 ± 20.5 years), and patients sustaining facial bone fractures, (35.4 ± 19.5 years). All differences were statistically significant ($p < 0.001$).

Table 1 – Description of the sample – cranio-maxillofacial trauma 1991–2000

Variable	9 543 Patients/21 067 incidents	
Age	Mean	25,82
	Standard deviation	19,94
	Minimum	0
	10percentile	4
	25percentile	10
	Median	22
	75percentile	37
	90percentile	55
	Maximum	98
Gender	Male	6474
	Female	3069
Injury type	Facial bone fractures	3578
	Dentoalveolar trauma	4082
	Soft tissue lesions	1733
Cause of injury	Adl	3613
	Sports	2991
	Assault	1170
	Traffic	1116
	Work	504
	Others	149
Mechanism of injury	Falls	4110
	Collisions with objects	662
	Struck by equipment	290
	Collisions with other person	656
	Lift accidents	52
	Traffic collisions	910
	Blows (e.g. by fist)	1773
	Others	194
	Undefined play accident	318
	Unknown	533
	Suicide (attempts)	12
	Deaths (on arrival)	33

Gender distribution

The ratio of 2:1 injured patients were men ($n = 6474$) compared with women ($n = 3069$). Men were at a higher risk than women for the first 70 years, with an almost three-fold risk of injury to males in the third and fourth decades. However, women had a higher likelihood of injury between 40 and 49 years (0.464) when comparing the male:female ratios of all age groups. Above 70 years of age, facial injuries predominated in women (Table 2).

Yearly and monthly distribution

The annual numbers of accidents treated showed an increase in the first few years levelling at about 1000 patients per year subsequently (Fig. 3). The monthly distribution peaked in the summer (August, 9.5%), but revealed further peak incidences during December (8.8%), January (9%), and February (8.9%). November figures were lowest (Fig. 4).

Nationality of patients

Apart from the 81% Austrians, there were 9% Germans, and 10% from other countries. Thus 19% of patients were from abroad (Fig. 5). The proportion of nationalities involved in skiing accidents were 44.5% German, 31.8% Austrian, 9.2% Dutch, 3.3% British, and 2% French and Italian.

Table 2 – Sex distribution of patients with cranio–maxillofacial injuries

Age	Cranio-maxillofacial trauma 1991–2000 ($n = 9543$)		
	Sex distribution		
	Female	Male	Female:male ratio
0 – 9	924	1399	0.660
10 – 19	572	1405	0.407
20 – 29	494	1456	0.339
30 – 39	309	910	0.340
40 – 49	246	530	0.464
50 – 59	171	394	0.434
60 – 69	106	220	0.482
70 – 79	136	102	1.333
80 – 89	97	51	1.902
90 – 99	14	7	2.000
Total	3069	6474	0.474

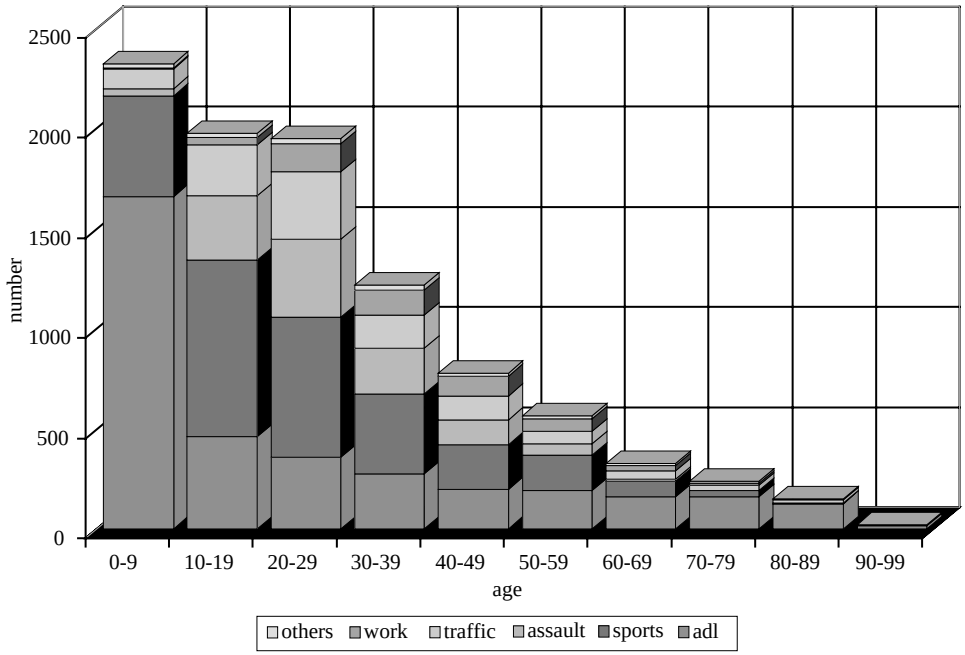

Fig. 2 – Age distribution of patients ($n = 9543$) with cranio-maxillofacial injuries ($n = 21067$).

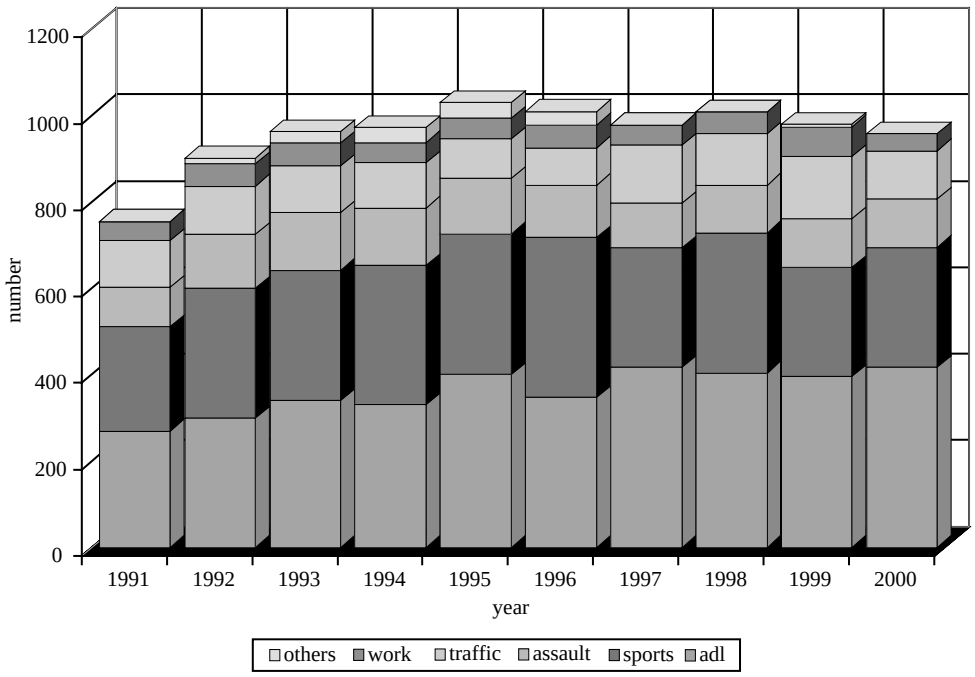

Fig. 3 – Yearly distribution of patients ($n = 9543$) with cranio-maxillofacial injuries ($n = 21067$).

Injury types

A total of 3578 patients (37.5%) had 7061 facial bone fractures (either in combination with dentoalveolar trauma and/or soft tissue lesions), 4763 patients (49.9%) suffered from 6237 dentoalveolar, and 5968 patients (62.5%) from 7769 soft tissue injuries separately. Of one hundred and fifty patients with non-facial injuries referred to the department for evaluation, a cranio-maxillofacial injury could not be confirmed (1.6%). The prevalence of the three injury types, and their combinations in all 9543 patients are displayed in Table 3 and the dominant injury type per accident is depicted in Fig. 6.

Facial bone fractures: Of the 7061 facial bone fractures, midfacial fractures accounted for 71.5%, mandibular fractures for 24.3%, and supraorbital

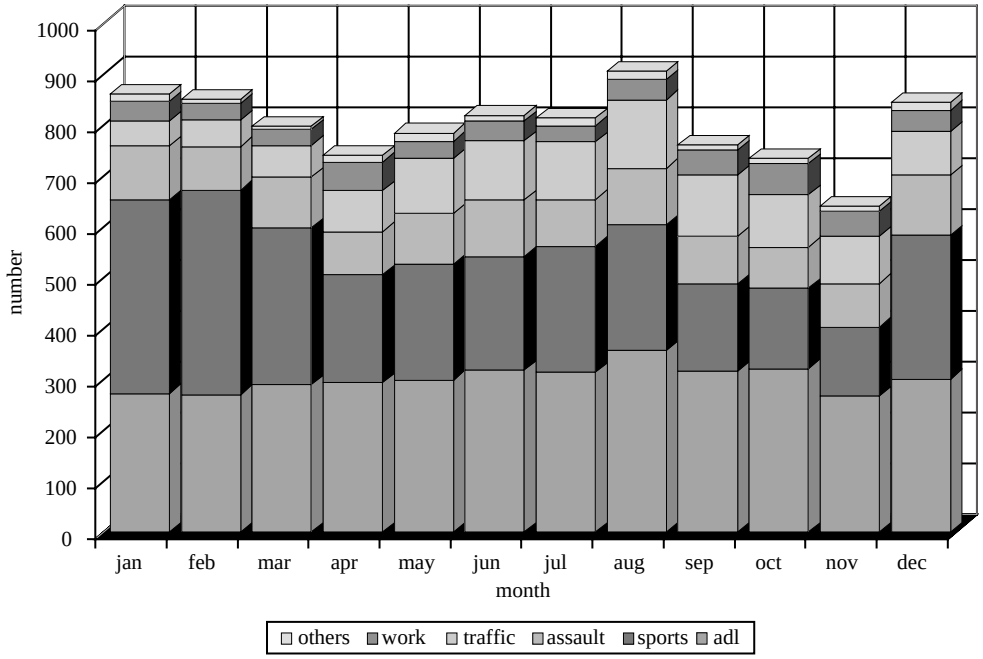

Fig. 4 – Monthly distribution of patients ($n = 9543$) with cranio-maxillofacial injuries ($n = 21067$).

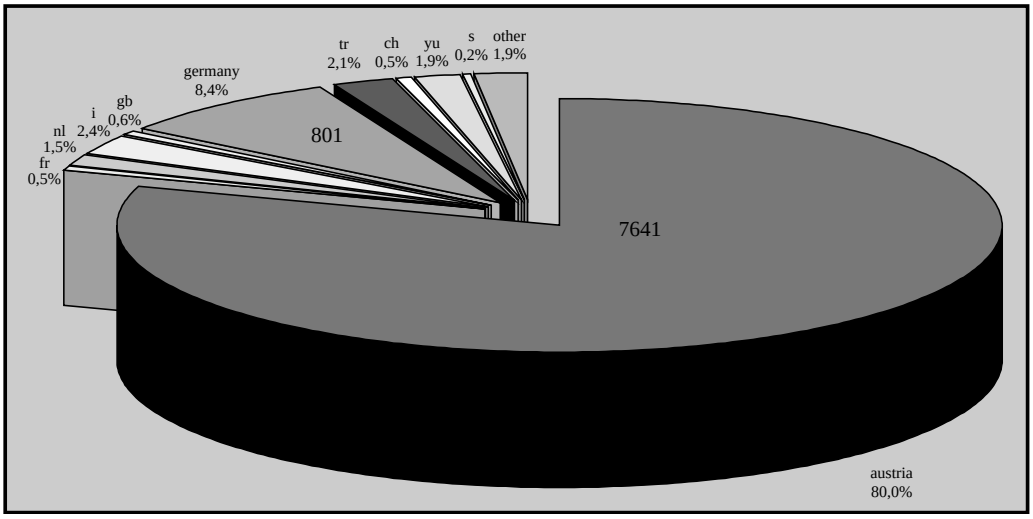

Fig. 5 – Nationality of patients.

Table 3 – Category of injury

All accidents	Number	Percentage
Category of injury		
Soft tissue lesions	1733	18.2
Dentoalveolar trauma	2327	24.4
Facial bone fractures	957	10.0
Soft tissue + Dentoalv.trauma	1755	18.4
Soft tissue + Bone fractures	1945	20.3
Dentoalv. + Bone fractures	145	1.6
Soft tiss. + Dentoalv. + Bone fract.	531	5.5
Injuries outside the face	150	1.6
Total	9543	100

and frontobasal fractures for 4.2% of the cases. Their distribution is listed in Table 4.

Soft tissue injuries: Of the 7769 soft tissue injuries, 41.3% were lacerations, 23.9% abrasions, 23.7% haematomata and 11.1% contused wounds. (Table 5).

Dentoalveolar trauma: In total, 37.8% of the 6237 dentoalveolar injuries were crown fractures, 2.8% root fractures, 47.9% were subluxations, 7.1% avulsions, 2.5% intrusions and 1.9% were tooth concussions (Table 6).

Concomitant injuries: Patients with cranio-maxillofacial trauma also suffered from severe associated

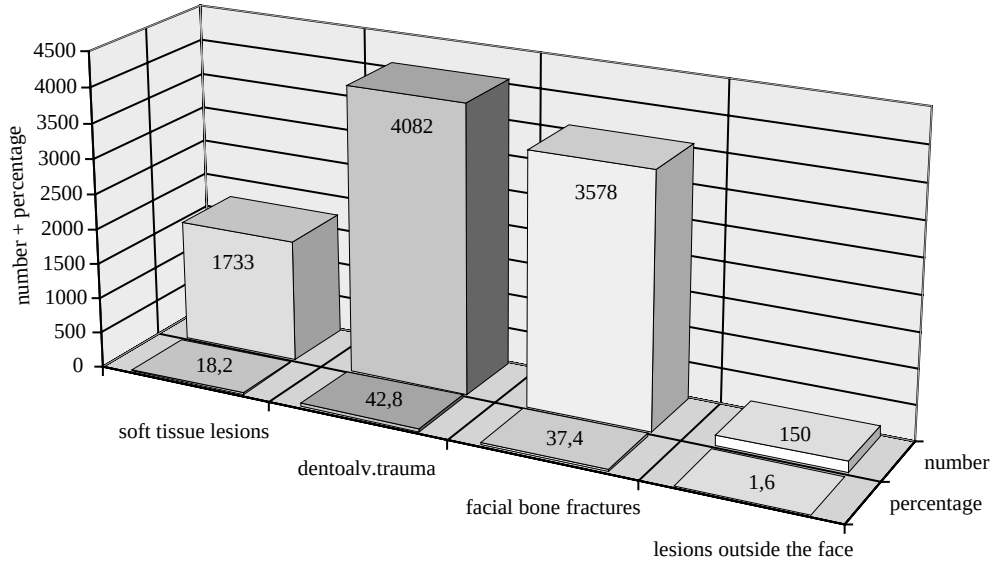

Fig. 6 – Dominant injury type/accident.

Table 4 – Facial bone fractures (7061) in 3578 patients (1991–2000)

Type of fracture	Number	Percentage
Supraorbital right	142	2.0
Supraorbital left	158	2.2
Le Fort I	145	2.1
Le Fort II	152	2.2
Le Fort III	104	1.5
Zygoma right	696	9.9
Zygoma left	747	10.6
Zygomatic arch right	248	3.5
Zygomatic arch left	287	4.1
Orbital floor right	740	10.5
Orbital floor left	836	11.8
Maxilla right	169	2.4
Maxilla left	158	2.2
Max alveolar process right	141	2.0
Max alveolar process left	122	1.7
Nose	496	7.0
Mandibular symphysis	93	1.3
Mandible right	350	5.0
Mandible left	384	5.4
Collum right	276	3.9
Collum left	314	4.4
Mand alveolar process right	75	1.1
Mand alveolar process left	78	1.1
Caput	150	2.1
Total	7061	100

Frontal bone fractures: 4.2%;
Midface fractures: 71.5%;
Mandible fractures: 24.3%.

injuries in 1866 cases (19.6%) sustaining 2535 injuries involving cranial nerve and head injuries, some necessitating operative treatment (data not shown).

Table 5 – Soft tissue injuries (7769) in 5968 patients (1991–2000)

Soft tissue injuries	Number	Percentage
Lacerations	3205	41.3
Excoriations	1855	23.9
Contusions	861	11.1
Haematomas	184	23.7
Total	7769	100

Table 6 – Dentoalveolar injuries (6237) in 4763 patients (1991–2000)

Dental trauma	Number	Percentage
Crown fractures	2356	37.8
Root fractures	176	2.8
Subluxations	2988	47.9
Avulsions	444	7.1
Tooth concussions	119	1.9
Intrusions	154	2.5
Total	6237	100

Regression analyses

The results of regression analyses are reviewed in Tables 7–9 showing highly statistically significant different mean ages of occurrence and injury mechanism for each injury type.

The risk of sustaining facial bone fractures increased each year, by 4.4%. Increased risks of 68% for facial bone fractures existed for males when compared with females. There was a 2.25–fold risk (225%) for facial bone fractures in traffic accidents. In contrast, the probability of suffering fractures was lower in work-related accidents (by 28%), in assaults (by 17%), and in ADL/play-accidents (by 47%

Table 7 – Logistic regression analysis. Facial bone fractures – all accidents ($n=9543$)

	Facial bone fracture					
	Yes	No	Significance crude	Odds ratio adjusted	Odds ratio 95% CI	Significance adjusted
Age	35.43±19.50 years	20.06±17.87 years	$p<0.001$	1.044 per year	1.042–1.047	$p<0.001$
Sex			$p<0.001$			
Female	950/3069 (31.0%)	2119/3069 (69.0%)		Reference		
Male	2628/6474 (40.6%)	3846/6474 (59.4%)		1.679	1.510–1.866	$p<0.001$
Accidents			$p<0.001$	Reference		
Traffics	672/1116 (60.2%)	444/1116 (39.8%)		2.238	1.968–2.544	$p<0.001$
Work	227/504 (45.0%)	277/504 (55.0%)		0.716	0.605–0.849	$p<0.001$
Sports	1203/2991 (40.2%)	1788/2991 (59.8%)		1.095	0.991–1.209	$p=0.074$
Violence	453/1170 (38.7%)	717/1170 (61.3%)		0.830	0.732–0.940	$p=0.003$
ADL and play	941/3613 (26.0%)	2672/3613 (74.0%)		0.526	0.475–0.583	$p<0.001$

Table 8 – Logistic regression analysis. Dentoalveolar trauma – all accidents ($n=9543$)

	Dentoalveolar trauma					
	Yes	No	Significance crude	Odds ratio adjusted	Odds ratio 95% CI	Significance adjusted
Age	17.96±15.64	33.64±20.67	$p<0.001$	0.955 per year	0.952–0.957	$p<0.001$
Sex			$p<0.001$			
Female	1639/3069 (53.54%)	1430/3069 (46.6%)		Reference		
Male	3124/6474 (48.3%)	3350/6474 (51.7%)		0.845	0.766–0.932	$p=0.001$
Accidents			$p<0.001$	Reference		
Traffics	438/1116 (39.2%)	678/1116 (60.8%)		0.829	0.729–0.944	$p=0.005$
Work	201/504 (39.9%)	303/504 (60.1%)		1.290	1.085–1.533	$p=0.004$
Sports	1533/2991 (51.2%)	1458/2991 (48.8%)		1.159	1.049–1.281	$p=0.004$
Violence	426/1170 (36.4%)	744/1170 (63.6%)		0.725	0.638–0.823	$p<0.001$
ADL and play	2117/3613 (58.5%)	1496/3613 (41.5%)		1.485	1.342–1.644	$p<0.001$

Table 9 – Logistic regression analysis. Soft tissue injuries – all accidents ($n=9543$)

	Soft tissue injury					
	Yes	No	Significance crude	Odds ratio adjusted	Odds ratio 95% CI	Significance adjusted
Age	28.72±20.47	21.00±18.02	$p<0.001$	1.020 per year	1.018–1.023	$p<0.001$
Sex			$p=0.298$			
Female	1896/3069 (61.7%)	1173/3069 (38.3%)		0.991	0.761–0.918	$p=0.848$
Male	4072/6474 (62.9%)	2402/6474 (37.1%)		Reference		
Accidents			$p<0.001$	Reference		
Traffics	813/1116 (72.8%)	303/1116 (27.2%)		1.576	1.383-1.797	$p<0.001$
Work	351/504 (69.4%)	153/504 (30.6%)		1.142	0.960–1.359	$p=0.133$
Sports	1904/2991 (63.7%)	1087/2991 (36.3%)		1.116	1.014–1.228	$p=0.025$
Violence	802/1170 (68.5%)	368/1170 (31.5%)		1.307	1.153–1.481	$p<0.001$
ADL and play	2027/3613 (56.0%)	1586/3613 (44.0%)		0.836	0.761–0.918	$p<0.001$

($p<0.05$)). Sport accidents, however, did not reveal statistically significant differences for fractures when compared with other injury mechanisms or types (Table 7).

Younger patients were at greater risk of dentoalveolar trauma (4.5% per year) when compared with older persons, and of 15.5% in females compared with males for facial trauma. In addition, the probability of suffering dentoalveolar trauma ($p<0.05$) was increased in work-related accidents by 29%, in sports by 16%, during assaults by 28%, and in ADL/play accidents by 49%, but reduced in traffic accidents by 17% (Table 8).

Furthermore, older people were more prone to soft tissue injuries with a rising risk of 2% per year of age, although no statistically significant differences were found between the sexes for soft tissue trauma. Finally, the probability of suffering soft tissue injuries ($p<0.05$) was raised in traffic accidents by 58%, in sports by 12%, during assaults by 31%, and in ADL/play-accidents by 16% (Table 9). Also, no differences existed for soft tissue injuries in work-related accidents.

DISCUSSION

Trauma is the leading cause of death in the first 40 years of life. In addition, traumatic injury has been identified as the leading cause of lost productivity, causing more loss of working years than heart disease and cancer combined. Fractures of the facial skeleton are a common component of multiple trauma resulting from motor vehicle crashes, and industrial accidents, but also from sports assaults and ADL accidents. Patients sustaining comminuted facial fractures present with poorer health outcomes than patients with less severe facial injury, and have substantially worse outcomes than average. There is a direct relationship between the severity of facial injury and patients reporting work disabilities (*Girotto* et al., 2001). The severely injured patients eventually at long-term follow-up report the greatest percentage of injury-related disability, such as visual problems, alterations in smell, difficulty with mastication, and breathing, and epiphora, preventing employment.

Trauma has always played a decisive role in the establishment of maxillofacial surgery as an independent specialty (*Hausamen*, 2001). Maxillofacial surgery, a relatively young medical specialty, fulfills all the necessary requirements to be the driving force and leading specialty in the field of facial trauma. Proper treatment of fractures was initially performed by applying intraoral wiring and splints, and later, facial fractures were treated with internal fixation using wires and most recently rigid osteosynthesis. Currently, there is a trend away from titanium to bioresorbable plates and screws for many indications and these might finally be replaced by bone glue. Modern techniques using medical-technical progress may include micro-robots and percutaneous, endoscopic tools to perform constantly changing treatment options such as minimally invasive or laser surgery. Basic research in biomechanics and tissue engineering should provide a profound change in our therapeutic scope (*Gassner*, 2002).

Moreover, the specialty must produce meticulous epidemiological studies to support its leading role in oral and maxillofacial trauma. This study assesses the epidemiology of cranio-maxillofacial trauma based on 9543 facial trauma patients with 21 067 injuries over 10 years registered in one centre and treated according to injury patterns. About 1000 patients per year were referred for treatment to this department, with the highest incidences in the winter-months. Almost one-fifth of the patients (19%) were from abroad, mainly due to the high frequency of injuries among tourists and those in vacation. The mean age was 25.8 years and the male:female ratio was 2.1:1. This age and gender distribution equals results reported in a recent study from Germany (30.7 years; 2.8:1; *Meyer* et al., 1999).

Injury causes

Activities of daily life (ADL) and play-accidents were the most common injury causes in this survey accounting for 38% of all accidents. ADL accidents dominated in elderly people from the sixth to the tenth decade. Women, showed high likelihood of ADL accidents even a decade earlier. A study on unintentional injuries in the general population revealed that depression in women, and alcohol consumption in general, clearly raise the risk of ADL accidents 1.5- and 2.5-fold, respectively (*Nordstrom* et al., 2001). Play-accidents dominated in the first decade of life. The boy:girl ratio of 1.5:1 differs in magnitude from other reports revealing boys to be more prone to trauma (*Oji*, 1995; *Zerfowski* and *Bremerich*, 1998). Children are uniquely susceptible to craniofacial trauma because of their greater cranial-to-body-mass ratio (*Haug* and *Foss*, 2000). Mandibular fractures were the most common with the condylar region being particularly affected. The greatest concern when treating the paediatric patient, is the effect of injury or treatment on growth and development. This is especially reflected in the literature of consequences after condylar fractures. Conservative treatment of condylar fractures during growth can result in good remodelling and good function of the condyle (*Strobl* et al., 1999; *Güven* and *Keskin*, 2001). This view is partly supported by observations of fracture healing of displaced condyles in an experimental model of adult rats showing simultaneous "repositioning" of the condyle via callus formation (*Teixeira* et al., 1998).

In contrast, *work-related accidents* accounted only for 5% of all causes. The probability of sustaining cranio-maxillofacial trauma at work was higher in individuals using tools or machines at work (1.5 to 7-fold increased risk) when compared with office employees and students. These injuries peaked in the third decade of life with a male:female ratio of 11.8:1. *Hächl* et al. (2002) reported on work-related trauma revealing that 45.4% sustained maxillofacial fractures, 31.7% suffered dentoalveolar, and 21.2% soft tissue injuries. One-fifth (20.7%) of all patients displayed concomitant injuries with cerebral and cranial trauma being the most common (*Hächl* et al., 2002).

In contrast to other reports (*Meyer* et al., 1999; *Le* et al., 2001) where *assaults* were the second most common cause of injury, the percentage of persons injured during acts of violence was low with 12% in this database. People in the third and fourth decades of life are most prone to assaults.

Several studies revealed *traffic accidents* as the leading cause of facial injury (*Gopalakrishna* et al., 1998; *Hogg* et al., 2000; *Iida* et al., 2001). Yet, in this series, 1112 traffic accidents accounted for only 12% of all cases, often affecting patients in the third decade of life. In general, traffic accidents were associated with more severe injuries than other causes. Although the installation of airbags in motor vehicles has reduced the morbidity and the mortality

following motor vehicle accidents, new types of facial trauma are attributable to airbag deployment (*Roccia* et al., 1998; *Mouzakes* et al., 2001).

Reports of cranio-maxillofacial *trauma due to sports* suggest incidence rates between 6% and 33% (*Hussain* et al., 1994; *Iida* et al., 2001; *Maladiere* et al., 2001). Our study revealed 31% were from sports accidents. This was the dominant cause of injury between the second and fifth decades of life. Among 44 other kinds of sports, skiing (31.8%), cycling (23.6%) and soccer (8.6%) were the most frequent reasons for sports-related cranio-maxillofacial trauma. Three other wintersports, namely sledge riding, ice sports (ice skating/ice hockey) and snowboarding, accounted for 4.5 %, 4.2 %, and 3.1%, respectively. Ball sports and swimming caused 3.3 % and 4.3 % of the cases, whereas other sports contributed less than 2.1% each (*Tuli* et al., 2002; *Gassner* et al., 2000a). The percentage of soccer-related injuries was higher elsewhere in Europe (up to 47%) where soccer is the dominant sport (*Hill* et al., 1998; *Maladiere* et al., 2001).

Injury types

The incidence of facial injuries occurring in conjunction with major trauma was shown in several surveys to range from 34% of 87 174 trauma patients in a North American Database on Trauma (Washington; *Sastry* et al., 1995) to 15% of 1088 trauma patients in Liverpool (*Down* et al., 1995), and 24.5% of 802 trauma patients in London (*Cannell* et al., 1996). Several authors addressed the problems with complex and severe facial injury in different facial regions. The most devastating are maxillofacial injuries due to blast effects causing comminuted fractures and defects to the face (*Shuker*, 1995). While therapy of frontal sinus fractures involving the anterior wall is well standardized and mostly treated without complications, management of anterior plus posterior wall fractures or injuries including the nasofrontal duct pose the risk of ophthalmic involvement (*Amrith* et al., 2000) as well as ascending infections affecting the anterior cranial fossa (*Gerbino* et al., 2000; *Joos* et al., 2001). In panfacial fracture patients, submandibular intubation may secure the airway (*Stranc* and *Skoracki*, 2000). Whilst *Schug* et al. (2000a,b) favoured titanium mesh for the treatment of complex mandibular fractures, such as extremely atrophic mandibles, mandibular discontinuity defects or comminuted fractures, others recommend conventional miniplate osteosynthesis in these circumstances (*Iatrou* et al., 1998).

In this study, 3578 patients sustained 7061 *facial bone fractures*, 4.2% of the fractures affected the supraorbital and frontobasal bones, 71.5% the midface, and 24.3% the mandible. A 5-year review of facial fractures noted an excess of mandibular fractures over zygomatic and maxillary fractures with a ratio of 6:2:1 (*Haug* et al., 1990), the frequency and distribution of 356 midfacial fractures occurring in 225 patients in California was discussed in a 4-year study (*Cook* and *Rowe*, 1990). Depending on the mechanism of injury during skiing, different cranio-maxillofacial injury patterns occur. Facial bone fractures are more likely in interpersonal collisions (80%), falls, and collisions with stationary objects (*Gassner* et al., 1996, 1999d). The major difference between bicycle and mountainbike accidents was that the latter resulted in a higher percentage (55%) of facial bone fractures, especially severe mid-face fractures such as LeFort I, II, and III, less dental trauma (22%) and more associated injuries; they especially affected males aged around 30 years (*Gassner* et al., 1999e).

In 4763 patients, 6237 *dentoalveolar injuries* were noted revealing a significantly lower age of 18 years in comparison with 35 years of age for facial bone fractures. The age-specific prevalence of trauma to the incisor teeth among individuals age 6–50 is estimated to be 24.9% in Americans (according to a study done by the NIDR; *Kaste* et al., 1996). The probability of suffering dentoalveolar trauma during skiing varied depending on the injury mechanism. There was a 3.5-fold risk for dentoalveolar trauma when hit by one's own equipment and a 8.5-fold risk during lift accidents (*Gassner* et al., 2000b). Bicyclists had 50.8 % dental injuries and 34.5% had facial bone fractures (*Gassner* et al., 2000c).

Of the 5968 patients, 62.5% sustained 7769 *soft tissue injuries* with a mean age of 29 years. Logistic regression analysis of the detailed data confirm the findings of others that falls and assaults result frequently in this type of injury. One craniofacial trauma study of 950 patients focusing on soft tissue injuries and bone fractures, revealed falls and assaults as principal aetiologic factors (*Hussain* et al., 1994).

In total, 1866 patients (19.6%) had 2535 concomitant injuries, especially cerebral and cervical spine injuries. Nearly 10% of patients with cranio-maxillofacial fractures sustained intracranial haemorrhages. Traffic accidents accounted for the most frequent cause of injury in these patients. Le Fort II and III, orbital, nasal, zygomatic and maxillary fractures, as well as cervical spine injuries, increase the risk of intracranial haemorrhage two to four fold (*Hohlrieder* et al., 2002). Head injuries and facial injuries have an increased risk of cervical spine injury (*Hills* and *Deane*, 1993). Concomitant cervical spine injuries were reported in less than 10% of all facial trauma patients (*Sinclair* et al., 1988). Previous case–control studies assessed the risk of cervical spine trauma and facial injury. An investigation based on cranio-maxillofacial injuries as a control group revealed reduced risks for additional cervical spine injuries in younger patients, females, absence of brain injury, and in patients suffering facial soft tissue lesions or dental trauma alone (*Hackl* et al., 2001a). A study having cervical spine injuries as the control group revealed a rising risk of facial injury with increasing severity of cervical spine trauma (*Hackl* et al., 2001b).

The management of severe cranio-maxillofacial trauma is challenging. To optimize patient care and outcome, an interdisciplinary approach by different specialties is required. At our hospital in Austria, the specialty of oral and maxillofacial surgery plays an integral role in interdisciplinary trauma care.

The initial management of complex facial features include impressions, model analysis, preparation of surgical splints and custom made arch bars if required. During surgery reestablishment of the *occlusion* is integral, and is facilitated by the use of occlusal splints. Multiple facial fractures demand anatomical reduction in all 3 dimensions.

CONCLUSION

By analysing the main effects of the injury mechanisms in cranio-maxillofacial trauma, this study revealed an accumulating risk of 4.4% per year to sustain facial bone fractures and 2% for soft tissue injuries. Younger persons are more susceptible to dentoalveolar trauma demonstrating a decrease of 4.5% per year of age. The severity and complexity of facial trauma not only requires interdisciplinary co-operation in the care of these patients but also asks for continued information of the lay public on the importance of preventive strategies. The latter remains the cheapest way to reduce direct and indirect costs of the sequelae of trauma.

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