Year: 2007

Evaluation of 591 patients with midface fractures treated between 1991 and 2001 in the Department of Maxillofacial Surgery, University Hospital Zurich

Zweifel, D F

Abstract: Introduction: Midface fractures represent a significant amount of the traumatological load handled by the Department of Maxillofacial Surgery (MFS), University Hospital, Zurich (USZ). Various fracture classifications have evolved from early descriptions of general patterns to modern, reproducible and computerised schematics. Although the modern classification systems are advantageous, particularly when it comes to statistical analysis and exact fracture recording, older systems prevail because of their simplicity. This is particularly true for the Le Fort and Rowe classification systems which are still in everyday usage. Objective: To quantify and analyse the number of midface fractures with associated facial fractures from 1990 up to and including 2001 operatively treated in the Department of MFS USZ as well as various social and general injury determinants. Materials and Methods: The hospitals databases and patient files were searched for relevant information and this was entered into a computerised dataset. Using SPSS software descriptive statistics and logistic regression were performed. Results: 591 patients suffered from 1588 fractures equalling 2.7 fractures per patient. 106 (17.9%) patients additionally suffered from 188 (11.7%) mandibular and 72 (12.2%) patients from a total of 83 (5.2%) supraorbital fractures in addition to their midface fractures. The fractures were split into categories defined in literature, fracture distribution to each other and to injury mechanisms were analysed and neural trauma, polytrauma and panfacial trauma reviewed separately. The average age was 39.4 years with a SD of 16.6 with a male peak at 25 to 30 years of age and a female peak slightly earlier at 20 to 25 years. The male to female ratio was 3:1 overall. The most common cause of injury was traffic accidents, followed closely by sports accidents and assault. Discussion: Our midface fracture population had more and more serious injuries than average according to literature. The results are discussed in detail.

Universität Zürich
Zentrum für Zahn-, Mund- und Kieferheilkunde
Vorsteher: Prof. Dr. med. dent. S. Palla
Klinik für Zahn-, Mund- und Kieferkrankheiten und Kiefer- und Gesichtschirurgie
Direktor: Prof. Dr. med. Dr. med. dent. K. W. Grätz

Arbeit unter der Leitung von Prof. Dr. med. Dr. med. dent. K. W. Grätz

Evaluation of 591 patients with midface fractures treated between 1991 and 2001 in the Department of Maxillofacial Surgery, University Hospital Zurich

INAUGURAL-DISSERTATION
zur Erlangung der Doktorwürde der Zahnmedizin
der Medizinischen Fakultät der Universität Zürich

vorgelegt von
Daniel Fritz Zweifel
von Niederurnen GL und Schänis SG

Genehmigt auf Antrag von Prof. Dr. med. Dr. med. dent. K. W. Grätz
Zürich 2007

Table of contents

Abstract

Introduction: Midface fractures represent a significant amount of the traumatological load handled by the Department of Maxillofacial Surgery (MFS), University Hospital, Zurich (USZ). Various fracture classifications have evolved from early descriptions of general patterns to modern, reproducible and computerised schematics. Although the modern classification systems are advantageous, particularly when it comes to statistical analysis and exact fracture recording, older systems prevail because of their simplicity. This is particularly true for the Le Fort and Rowe classification systems which are still in everyday usage. **Objective:** To quantify and analyse the number of midface fractures with associated facial fractures from 1990 up to and including 2001 operatively treated in the Department of MFS USZ as well as various social and general injury determinants. **Materials and Methods:** The hospitals databases and patient files were searched for relevant information and this was entered into a computerised dataset. Using SPSS software descriptive statistics and logistic regression were performed. **Results:** 591 patients suffered from 1588 fractures equalling 2.7 fractures per patient. 106 (17.9%) patients additionally suffered from 188 (11.7%) mandibular and 72 (12.2%) patients from a total of 83 (5.2%) supraorbital fractures in addition to their midface fractures. The fractures were split into categories defined in literature, fracture distribution to each other and to injury mechanisms were analysed and neural trauma, polytrauma and panfacial trauma reviewed separately. The average age was 39.4 years with a SD of 16.6 with a male peak at 25 to 30 years of age and a female peak slightly earlier at 20 to 25 years. The male to female ratio was 3:1 overall. The most common cause of injury was traffic accidents, followed closely by sports accidents and assault. **Discussion:** Our midface fracture population had more and more serious injuries than average according to literature. The results are discussed in detail.

Introduction

General

The University Hospital of Zurich (USZ) treats 188'500 patients each year of which 159'000 are outpatients and 29'500 are hospitalised. 1076 outpatients and 699 hospitalised patients were operated on by the Department of Maxillofacial Surgery (MFS) in 2005 [1] which makes it the largest clinic of it's kind in Switzerland. An extensive maxillofacial polyclinic and a polyclinic for oral surgery are attached to the institute and treated 3919 and 5974 patients respectively.

This study is a review and an analysis of all midface fractures treated by the MFS in the USZ from 1991 up to and including 2001.

Facial fractures are presented by roughly 10% of patients admitted to trauma centres [2] and around 70% of those are midface fractures [3]. The midface is vertically defined as the area between the upper alveolar process and the orbital and ethmoidal roof, expands laterally to the zygoma and ends posteriorly at the sphenoid and ethmoid sinuses [4]. These fractures are sometimes diagnosed by the patients private dentist, sometimes by a trauma team and are sometimes set aside due to injuries that need to be treated first. The patients included in this study are drawn from all forms of referrals both national and international but the majority was diagnosed in the emergency ward of the USZ by the MFS and resident trauma teams.

There is a large variation in fracture distribution and injury mechanism depending on both the country of origin of the study [5] [6] and the urbanity of the hospital conducting the study [7] [8] [9]. Zurich is the largest urban area in Switzerland and the USZ provides craniomaxillary service for patients from the city and from the surrounding more rural areas including the eastern and southeastern part of Switzerland as well as all cities in those regions. The population therefore is very mixed and patients are from all walks of life, ranging from the injured farmer to the assaulted student.

Fracture classification

Since Dr. Rene Le Fort's seminal work [10] published in 1901 midface fractures are defined as being at level I, II and III. These were defined after many experiments inflicting blunt trauma on cadavers. The bilateral split through the lower buttresses of the midface separating the dento-alveolo-palatal section of the maxilla from the upper was named level I. Level II parts the complete maxilla and nasal cavity from the upper midface and level III severs the entire facial skeleton from the cranial base, so called disassociation.

As these fracture patterns are common in midface trauma and can be used to quickly describe both uni- and bilateral fracture patterns across defined levels the terms are still very much in common usage. In 1927 Le Fort II and III were split into Wassmund I to IV depending on whether a naso-orbito-ethmoidal (NOE) fracture is present or not [11]. Other names for Le Fort fractures are common. Level I is often called a Guérin fracture while level II is frequently referred to as a pyramidal fracture [12].

Rowe [13] defined facial fractures according to clinical relevance and described their patterns by way of four distinct regions. Region I encompasses the lateral midface with zygoma and orbital floor, region II the nasomaxillary complex around the piriform aperture, region III the nasoethmoidal complex and region IV the dentoalveolar complex. This permits a grouping of fractures into lateral, central and centrolateral categories.

For most types of local bony injury very precise definitions are available. NOE fractures for example are separated into three levels of comminution, frontal sinus injuries divided into 4 types according to Freihofer and Ioannides or a different 4 according to Gonty et al [12].
These local definitions are ideal for the description of common isolated fractures or individual parts of a series of fractures but can fall short when compound fractures encompass more than one segment of the midface. Considering the complexity of the

midface with its horizontal and vertical buttresses, its sinuses and soft tissues every attempt at a classification of midface fractures is a challenge.

In 1989 Cooter et al. [14] designed an alphanumeric coding system for fractures of the facial skeleton. This enabled amongst other things the depiction of the severity of injury to the bony region as well as a computer based statistical evaluation and database building.

Today's AO (Arbeitsgemeinschaft für Osteosynthesefragen) definitions [15] aren't solely reliant on the bony structure of the facial skeleton to describe the severity of individual fractures but also rate the overlying soft tissue and vascular support based on earlier publications [16] .

Buitrago-Tellez (2002) [17] defined facial fractures radiologically along the lines of the AO long-bone fracture system providing a very precise description and making scoring facial trauma victims reproducible.

This study

The inherent issue with the newer classification systems as mentioned above is their complexity. This arises from the necessity to incorporate any variation of fracture type in a very complex facial bone structure. In everyday usage the older more intuitive fracture classifications such as the Le Fort fractures prevail, as was the case during the 11 years which this study spans. For this reason we collected classification data as stated by the surgeons themselves. These were either direct specific descriptions of the fractured bones or uni- or bilateral Le Fort levels.

Objective

To identify, describe and discuss all midface fractures patients operatively treated at the Department of Maxillofacial Surgery in the University of Zurich. Additionally the relationship between the fractures themselves and various social and general injury determinants was to be established.

Materials and methods

Hardware: Apple PowerBook G4 running OSX version 10.4.7, ADSL online connection
Software: 'Opera' browser (Opera Software ASA, version 9.01), 'Word' and 'Excel' (Microsoft Corporation, v.X for Mac), 'Bookends' reference manager (Sonny Software, Version 9.0.6), 'SPSS' statistics (SPSS Inc, version 11.0.4 for Mac).

A literature search was performed online utilising the PubMed access feature in 'Bookends' and a number of combinations of keywords and their plurals (fracture, trauma, facial, midface, maxillofacial). All results were screened for relevance but since 'facial fracture' yielded 4500+ results only the last 10 years (1250 articles) up until 1996 were vetted. All results were combined into one dataset comprising roughly 300 articles ordered by content. This dataset was used for study purposes through university online access to full-text articles and to compile the reference list for this article. Textbook sources were added manually.

Facial fractures were classified according to Schuknecht et al. [4] , the adaptations of which are mentioned in *Table 1*.

Lists of all operations performed by the Maxillofacial Department in the University of Zurich were evaluated from 1991 up to and including 2001 and all patients with operatively treated midface fractures were entered into an 'Excel' master-spreadsheet. These names, birthdates and dates of operation were compared to the individuals operation protocol filed for the relevant years and copies of files were made. All patients were entered into the hospitals patient administration program and relevant data was extracted and entered into the spreadsheet. Printouts were made. Patient records were individually sought out in the archives and data entered into the spreadsheet. Where applicable copies were made. The copies of patient files were used to revalidate all data in the master-spreadsheet.

‘Excel’ data was sorted by fracture type and separate spreadsheets were made.

‘Excel’ data was converted into numerical values in preparation for SPSS analysis. All files imported into SPSS were used to perform descriptive statistics and binary logistic regression.

Graphs were created using ‘Excel’ or by importing ‘SPSS’ results, tables using ‘Word’ or by importing ‘SPSS’ results.

This study inevitably relies to a large extent on the estimation of fracture classification by the person writing up the patient’s history. All files were screened and in the few instances where no classification was given it was defined by the author by way of the operation and X-ray protocols.

Results

All patients with midface fractures were considered for this study no matter what the concomitant injuries. Isolated mandibular and frontal fractures were disregarded.

Each clearly defined fracture type was noted as one fracture. A Le Fort III injury for instance was noted as one fracture, a comminuted fracture of the zygomatic arch was also counted as one fracture. This is consistent with literature [3].

Out of a total of 601 patients found in the operation lists from 1991 up to and including 2001 7 had to be disregarded due to unobtainable files and 3 due to a lack of fracture information. The remaining 591 patients were included in the analysis.

No injury mechanism could be found in 19 files and no age determined in 4. Both issues are mentioned in the relevant sections.

No injury severity score was recorded.

Number of fractures

We found a total of 1588 fractures in 591 patients which equals 2.7 fractures per patient. 106 (17.9%) patients with midface fractures additionally suffered from 188 (11.7%) mandibular fractures. This equals 1.7 fractures per injured mandible. Supraorbital fractures were found in 72 (12.2%) patients. These patients suffered from a total of 83 (5.2%) fractures which is equal to 1.2 fractures per frontally injured patient. 1317 (83.1%) fractures were located in the midface.

In summation 11.7% were mandibular, 83.1% midface and 5.2% were supraorbital and frontobasal fractures.

Figure 1 illustrates the number of fractures per individual year, while *Figure 2* demonstrates the cumulative number of patients per month split by year.

During the 11 years of this survey an average of 53.7 midface fracture patients was treated every year. August was the busiest month with an average of 6.2 midface fractures.

The cumulative number of every fracture type recorded is listed in *Table 2*.

All **mandibular** fractures are split into prevalences of individual locations and are separately listed in *Figure 3*. Only combinations with midface fractures were considered.

Fractures of the **anterior table of the frontal sinus** occurred in 40 cases. These were combined with a fracture of the **posterior table** in 24 cases, equalling 60% of all frontal sinus fractures.

Of the 83 **supraorbital** fractures 40 involved the frontal sinus, 23 involved the frontal calvaria, 12 the orbital roof, 1 the sphenoid sinus and seven could not be attributed to a specific fracture but were mentioned in the patient history.

Frontobasal lesions were mentioned in 63 patients. Every care was taken to attribute them to the correct fractures, in 7 cases however the diagnosis was mentioned without specific location.

The most common cause of frontobasal injury was the fracture of the posterior table of the frontal sinus at 24 cases, second a fracture of the orbital roof at 12 cases. The following were also found; Le Fort III lesions with NOE in 8 cases, isolated NOE in 6 cases, frontal calvaria in 5 cases and in one case the sphenoid sinus. As can be seen the frontobasal group draws both from the supraorbital and the midface group of fractures according to its definition as a pathological communication between the intracranial region and the outer world.

In addition to the fractures mentioned above one patient was treated for an isolated unilateral fracture of the **anterior wall of the maxillary sinus**.

Fracture distribution

All fractures found were crosstabulated, resulting in *Table 3*. It shows the number of patients that suffer from two fractures simultaneously as well as the total amount for each fracture. Variables like panfacial-, poly- and neurotrauma are also listed.

In order to elucidate the relationships between individual fractures binary logistic regression was performed. Significant association was defined as a p-value of 0.05 or lower, exceptions are noted. All associations are listed in *Table 5* below.

According to the criteria in *Table 1* all fractures were classed as central, centrolateral or lateral or a combination; combined centrolateral. *Figure 4* shows the amount of patients in each category.

Considering the 14 variables analysed for each patient 16'384 combinations of fractures are possible. In the 591 patients analysed we found 168 fracture patterns. Of these only 47 were presented by 2 or more patients, the other 121 patterns were singular. With the exception of 18 isolated Le Fort I fractures all patterns with 10 or more patients are in the lateral midface category and are listed in *Table 6* below.

Of the 65 pure central midface fractures only 8 did not have a Le Fort fracture; They were all naso-orbito-ethmoidal fractures.

A number of other combinations of fractures were found. In the Le Fort fracture class combinations of each level were noted and graphically displayed as *Figure 5*.

Fractures tended to be side-dominant, meaning that if multiple fractures are present they tended to be on the same side of the face. An example is given in *Table 7*. Crosstabulation was performed for all side-specific fractures and relevant combinations are mentioned in the discussion section.

Injury mechanism

19 patient records were incomplete as to the way the injury was sustained and were omitted from the following results. *Table 8* lists all fractures as a function of the injury mechanism that caused them. The average age for injury mechanisms and fracture types are also listed (see age section).

In order to demonstrate more generally the injury mechanisms the following *Table 9* groups them into categories.

The injury mechanisms were sorted by month in order to find patterns. Some patterns were predictably season-centred, for instance cycling (*Figure 6*), motorbiking, slips, soccer accidents or skiing. Others demonstrate no obvious pattern; assaults (*Figure 7*), car crashes, injured equestrians.

The three gunshot injuries were all self-inflicted and there was one in January, one in March and one in April.
Pedestrians were most commonly hit by cars in July, compression traumas and tram accidents were also summer occurrences. Train related accidents occurred in the autumn.

Gender

448 patients were male and 143 female which sets the male to female ratio at 3:1. This is consistent with literature [3, 18, 19, 20, 21].

Figure 8 is a graphic display of *Table 10*. It shows the injury mechanisms both as a function of male and female gender as well as an aggregate number. *Table 11* shows the regrouped categories of *Table 10*.

In order to illustrate the relationship between gender and individual fractures *Table 12* was devised. The amount of patients of each gender suffering from each fracture is given.

Age, neural-, panfacial- and polytrauma are discussed in the relevant sections below.

Age

Four patient records were incomplete as to their age and they were omitted from further analysis. The average overall age was 39.4 years with a SD of 16.6. Average age was slightly lower in the male population at 38.9 years and slightly higher in the female at 40.7. The youngest patient was 6.4 years old, the oldest 89.8.

As can be seen in *Figure 9* there is a clear peak in injury frequency in the 25 to 30 year age group for the total number of midface fractures. This corresponds to the male peak, the female peak being between 20 and 25 years of age.

The average age of each fracture and injury mechanism can be seen above in *Table 6*. Age as related to neurotrauma, panfacial and polytrauma is listed in the relevant sections below.

Neurotrauma

150 patients suffered neural trauma ranging from concussion to direct cerebral lesion with open cranial calotta.

Age distribution (*Figure 10*) shows little difference to midface trauma without neural involvement.

Neural trauma is strongly associated with car crashes, cycling accidents, motorcycling, being hit by a car, falling from a significant height and compression trauma, as seen in *Table 13*.

Associations with individual injuries are shown in *Table 14*.

Sex: 120 men and only 20 women had neural trauma which results in a ratio of 6:1.

Panfacial injuries were associated with neural trauma in 87.5% and comprised 9.3% of all neural trauma.

Polytrauma patients suffered from neural trauma in 53.3% of cases and comprised 16% of all neural trauma.

Frontobasal lesions were mentioned in 63 patients. 46 (73%) of these suffered from neural trauma as recorded.

Panfacial trauma

16 patients suffered from panfacial trauma, four of them were associated with polytrauma. 8.9% of polytraumatised patients with midface fractures had panfacial trauma.
If all midface trauma patients are considered 2.7% suffered a panfacial trauma.

Two peaks for panfacial injury can be made out in *Figure 11*; the first and most striking one between the age of 25 and 30, the second between 50 and 60.

Injury mechanisms: 5 car crashes, four bicycle accidents, 3 falls from significant height, one patient had a motorcycle accident, one was hit by a heavy plank, one was kicked by a horse and one patient was run over by a train.

Sex: 14 men and 2 women were recorded having panfacial fractures, a ratio is 7:1.

Panfacial fractures were found to be significantly associated only with mandibular fractures.

Only 4 panfacial traumas were associated with **polytraumatised** patients, whereas 14 of 16 patients with panfacial injuries also suffered from some noted form of **neural** trauma.

Polytrauma

45 cases of polytraumatised patients were recorded. Of these 32 (71.1%) were male and 13 female. The male to female ratio is 2.5:1.

A number of peaks in age are shown in *Figure 12*. 25 to 30, 35 to 40 and 55 to 60 years are the most significantly hit age groups.

Causes of polytrauma with midface involvement can be almost exclusively limited to car crashes, falls from significant height and motorcycle accidents as seen in *Table 15*.

According to binary logistic regression polytrauma is significantly associated with mandibular fractures, frontobasal lesions and neurotrauma.

Discussion

On average 7.7% of all operations performed by the Department of Maxillofacial Surgery (MFS) in the University Hospital of Zurich (USZ) were performed to treat midface fractures. At 591 patients and 1588 fractures the study group is of an average size as compared to earlier publications [8 22 23].

The amount of fractures we found per patient was 2.7. This is higher than the results of Bo et al. [8] who found an average of 1.7 fractures per person in his 10 year study of 1693 maxillofacial fractures and only slightly higher than the results of Gassner et al. [3] who note 2.2 fractures per patient.

Our 1588 fractures can be grouped by levels resulting in 5.2% supraorbital, 11.7% mandibular and 83.1% midface fractures. In their large study of facial fractures Gassner et al. [3] noted 4.2% supraorbital, 24.3% mandible and 71.5% midface fractures.

Supraorbital fractures

Patients with supraorbital fractures are slightly younger than average (*Table 8*), tend to be male (*Table 12*) and their most common injury mechanisms are traffic accidents (*Table 8*). Injury mechanisms with a high impact force such as cyclists or motorbikers falling from their vehicles or falls from height, compression trauma or train related accidents had the highest risk of resulting in supraorbital fracture. It can not be discerned retrospectively whether the force of impact was directed to the frontal region itself or if the midface gave way after absorbing as much force as it could. It can however be said that 17 of 23 patients with a fracture of the frontal calvaria also had a fracture of the zygoma (*Table 4*) and other midface fractures abound.
Neural trauma has an above average prevalence in supraorbital fractures (*Table 4*).

It is therefore fair to say that accidents resulting in the fracture of supraorbital structures tend to be more violent than average trauma resulting in facial fracture.

Combinations of fractures of both the anterior and posterior table of the frontal sinus were more common with our patients than mentioned in literature at 60%. Gossman et al. [24] mention 50% combinations and Zapala et al. [25] note 50.5%.
The orbital roof is reported to be involved in 1 to 9% of facial fractures according Haug et al.'s [26] extensive review of relevant literature. 2.2% of our patients suffered from orbital roof fractures.
Frontobasal trauma was found in 10.7% (63) of patients where Pappachan et al. [27] found a 14% combination rate of cranial injury and facial fracture in their study of 772 facial fracture patients in India.

Mandibular fractures

Gassner et al. [3] found the fractured mandible to be the most common single fracture. Since we only considered mandibles when combined with midface fractures our results show it to be the fourth most common fracture after the zygoma, the arch and the orbital floor. We found 1.8 fractures per injured mandible, consistent with the results of Rhea [28] who notes an average of two mandibular fractures per patient. Women are more susceptible at 23.1% as compared to men at 16.3% (*Table 12*), mandibular fracture patients are younger than average (*Table 8*) and the most common causes are car crashes, cycling and other traffic accidents (*Table 8*). One third of all car or motorcycle crash victims had at least one mandibular fracture while gunshot injuries, train related injuries and compression traumas had the highest level of association.

The most common type of mandibular fracture found in our population was that of the condyle closely followed by the paramedian fracture (*Table 3*). While paramedian fractures were mostly unilateral 41% of patients with condylar fractures suffered from them bilaterally. Zachariades et al. [29] noted bilateral injury in 26.6% of 368 patients suffering from condylar fractures.

If a condylar fracture is associated with other mandibular lesions it is most likely to be the paramedian or median fracture. Common combinations of mandibular fractures were median or paramedian with condylar fractures, paramedian and corpus fractures and paramedian and angle fractures. Though our numbers are very small the following tendency can be hypothesized; If the combination of median and condylar fracture occurs it is usually a bilateral condylar fracture (4 cases as compared to 2 single sided collum fractures). Combinations of paramedian or angle with condylar fractures and the combination of paramedian and corpus fractures tend to associate with the contralateral side. Most other fractures tend to be ipsilateral if combined.

Interpretation of percentage variations to literature

Generally speaking the above results are consistent with literature. One explanation for the deviation from published percentages has to be that by disregarding isolated mandibular and frontal fractures we preselected our study group to be more seriously injured than the average facial trauma patient. Obviously geographic considerations and society could also play a role such as the way Swiss medical resources are organised regionally so that only more seriously injured patients are referred to last-level maxillofacial clinics.

Midface fractures

The majority of our patients suffering from midface trauma suffered from lateral midface fractures (*Figure 4*). A minority of those additionally suffered from supraorbital and/or mandibular fractures (*Table 6*). Over 75% of the patients treated for a midface fracture suffered from an injury to the zygoma making it the most common fracture in this study (*Table 2*). The most common isolated fracture was again the zygoma (*Table 6*) with 105 cases.

The zygoma has an exposed position in facial structure. It acts as a link between all levels and a support, superiorly forming the bottom of the ocular cavity and connecting to the frontal bone, posteriorly defining the sagittal dimension of the face together with the arch and transversally defining facial width to a large degree. It is no surprise therefore that it should be the most commonly fractured midface bone.

Zygoma and arch fractures are very common in most injury mechanisms and do not exhibit preference for any type of injury mechanism.

Of the isolated zygoma fractures only 5.7% were comminuted compared to 17.6% if all zygoma fractures are considered (*Table 2*). This indicates that when sufficient force to produce a comminuted fracture is applied to the facial skeleton, the zygoma is most likely not the only thing to break.

When zygoma fractures are compared to fractures of paired facial bones there is a remarkable consistency in that most of the fractures are ipsilateral. This is the case for the orbital floor (*Table 7* as an example), the zygomatic arch and the angle, ascending ramus and coronoid process of the mandible. The corpus, paramedian and median portions of the mandible show roughly the same numbers of ipsi- and contralateral zygomatic fractures. No matter which side the zygoma fracture is on, bilateral fractures of the condyle are quite common. Left zygoma fractures are associated with both left and right condylar fractures whereas right zygoma fractures rarely have any concomitant condylar fractures at all. Left zygomatic fractures are more common than right ones (*Table 2*) at a rate of 1.3 to 1. A significant deviation towards the left can be seen in the injury mechanisms 'assaults' and 'slips' (not published). It could be hypothesised that since most people are right handed they could either better protect their right side when attacked or catch themselves when slipping and falling towards the right hand side. This would result in more force when the left side is injured which incurs more fractures and more concomitant injuries.

Patients suffering from central and centrolateral fractures are slightly older than people suffering from lateral midface fractures alone. The injury mechanisms most likely to produce central midface fractures are car crashes (Table 8). Traffic accidents generally have a high level of association, much higher for instance than assaults or slips, which showed relevant association only for Le Fort I and nasal fractures. Falls and compression traumas are other mechanisms that tend to create central or centrolateral fractures.

For the most part central and combined centrolateral fractures were Le Fort fractures (*Figure 4*, *Figure 5*). In the 46 cases where that was not the case, the fracture was either a NOE or a frontobasal fracture with or without lateral midface involvement. Both central and centrolateral fractures show a higher prevalence of neural trauma (*Table 4*) than lateral midface fractures. Roughly 1/3 to 1/2 of the central fractures nave neural trauma, Le Fort even has 2/3, whereas in injuries of the lateral midface only 1/4 of patients experience neural trauma of any form.

General

Men suffered more sports injuries, more involuntary contacts and more assaults, more supraorbital and NOE fractures and more polytraumas combined with midface fractures and suffered from significantly more panfacial trauma than women (*Table 11*). The ratio was 7:1 and the frequency peaked at 25-30 years of age (*Figure 11*).

Women incurred more traffic related injuries and slips but were assaulted significantly less often. The combination of mandibular and midface fracture was significantly more common (*Table 11*).

These results seem to indicate that men are more prone to risky behaviour and suffering injury more often is part of the risk. Women on the other hand have a higher life expectancy than men. More than half of the female patients injured in slips are 60 years old or older compared to only a third of the men in the same age-group.

Tables and Figures

Tables

Table 1 **Adaptations to classification of midface fractures**

Comminuted fractures	one level of comminution as noted in operating protocol
Mandibular fractures	symphyseal, parasymphyseal, body, angle, ramus, condyle, coronoid process
Dentoalveolar fractures	dental and alveolar process fractures. Only marginally reviewed since seldom specifically stated
Central midface	Le Fort I and II, nose, naso-orbito-ethmoidal (NOE), sagittal maxillary split
Centrolateral midface	Le Fort III
Lateral midface	zygoma, arch, orbital floor and lateral wall
Combined centrolateral	any combination of central, centrolateral and lateral
Frontobasal	any fracture of frontal and basal calvaria (i.e. orbital, ethmoidal and sphenoidal roofs)
Frontal calvaria	frontal bone excluding anterior wall of frontal sinus
Frontal sinus	anterior wall of frontal sinus
Panfacial trauma	combined mandibular, midface and frontobasal fracture
Polytrauma	serious injury in multiple organ systems
Neurotrauma	any noted neurological involvement, ranging from concussion to physical cerebral damage

Table 2 **Number of fractures**

	Zygoma	**Arch**	**Alveolar ridge**	**LeFort I**	**LeFort II**	**LeFort III**	**Sagittal maxill.**	**Nose**	**NOE**	**Orbital floor**	**Frontobasal**	**Frontal**	**Frontal sinus**	**Mandible**
Left	235	98		13	11	6				123				
Right	179	83		18	4	3				94				
Bilateral	34	19		92	45	26				22				
Ttl fractures	482	219	27	123	60	35	16	53	40	261	63	23	40	188
Ttl patients	448	200	27	123	60	35	16	53	40	239	63	23	40	107
Comminuted	85			29	23	12								

Table 3 **Distribution of mandibular fractures**

	Total	**Right**	**Left**	**Bilateral**
Median	15			
Paramedian	52	17	23	6
Corpus	20	5	9	3
Angle	21	13	8	
Ascending ramus	6	4	2	
Condyle	65	12	15	19
Coronoid process	9	4	5	

Table 4 **Crosstabulation of all fractures**

	Zygoma	Arch	Alveolar ridge	LeFort I	LeFort II	LeFort III	Sagittal maxil. split	Nose	NOE	Orbital floor	Frontobasal	Frontal calvaria	Frontal sinus	Mandible	Neurotrauma	Panfacial trauma	Polytrauma
Zygoma	448	167	17	73	35	20	10	33	21	195	42	17	24	85	116	13	37
Arch	167	200	9	30	10	10	5	12	10	87	22	8	11	45	48	8	16
Alveolar ridge	17	9	27	13	4	2	5	5	3	12	2	1	1	11	11	1	3
LeFort I	73	30	13	123	23	15	11	24	7	49	15	7	9	34	42	8	17
LeFort II	35	10	4	23	60	10	5	13	9	31	14	3	9	20	22	6	7
LeFort III	20	10	2	15	10	35	5	7	8	19	16	3	9	15	18	7	5
Sag maxill split	10	5	5	11	5	5	16	5	4	9	4	2	1	6	10	1	0
Nose	33	12	5	24	13	7	5	53	0	25	6	1	4	6	20	1	6
NOE	21	10	3	7	9	8	4	0	40	15	22	8	18	10	21	4	2
Orbital floor	195	87	12	49	31	19	9	25	15	239	28	9	15	50	69	9	25
Frontobasal	42	22	2	15	14	16	4	6	22	28	63	19	32	20	46	16	12
Frontal calvaria	17	8	1	7	3	3	2	1	8	9	19	23	12	9	20	6	2
Frontal sinus	24	11	1	9	9	9	1	4	18	15	32	12	40	7	27	5	3
Mandible	85	45	11	34	20	15	6	6	10	50	20	9	7	107	44	16	18
Neurotrauma	116	48	11	42	22	18	10	20	21	69	46	20	27	44	150	14	24
Panfacial trauma	13	8	1	8	6	7	1	1	4	9	16	6	5	16	14	16	4
Polytrauma	37	16	3	17	7	5	0	6	2	25	12	2	3	18	24	4	45

Amounts are given as patients suffering from both fractures simultaneously. Dark grey numbers are total amounts of fractures recorded.

Table 5 **Association after logistic regression**

Fracture	related to	P-value	association
Zygoma	Arch	0.054 (almost)	*Pos*
	Orbital floor	0.006	*Pos*
	LeFort I	0.000	*Neg*
	LeFort II	0.041	*Neg*
	NOE	0.034	*Neg*
Arch	Zygoma	0.048	*Pos*
	Mandible	0.036	*Pos*
	LeFort II	0.048	*Neg*
Alveolar ridge	LeFort I	0.034	*Pos*
	Sagittal maxill. Split	0.012	*Pos*
	Mandible	0.008	*Pos*
LeFort I	Sagittal maxill. Split	0.009	*Pos*
	Nose	0.003	*Pos*
	Mandible	0.018	*Pos*
	Zygoma	0.000	*Neg*
LeFort II	Nose	0.006	*Pos*
	Orbital floor	0.04	*Pos*
	Mandible	0.002	*Pos*
	Arch	0.008	*Neg*
LeFort III	Mandible	0.002	*Pos*
	Frontobasal	0.001	*Pos*
Sagittal split maxilla	NOE	0.013	*Pos*
	Alveolar ridge	0.003	*Pos*
	LeFort I	0.004	*Pos*
	LeFort III	0.045	*Pos*
Nose	LeFort I	0.003	*Pos*
	LeFort II	0.007	*Pos*
	Mandible	0.027	*Neg*
NOE	Frontobasal	0.028	*Pos*
	Frontal sinus	0.000	*Pos*
	Sagittal split maxilla	0.005	*Pos*
	Zygoma	0.051 (almost)	*Neg*
Orbital floor	Zygoma	0.004	*Pos*
Mandible	Arch	0.053 (almost)	*Pos*
	Alveolar ridge	0.004	*Pos*
	LeFort I	0.025	*Pos*
	LeFort II	0.003	*Pos*
	LeFort III	0.004	*Pos*
	Nose	0.019	*Neg*
Frontobasal	Frontal sinus	0.000	*Pos*
	Frontal calvaria	0.000	*Pos*
	LeFort III	0.001	*Pos*
	NOE	0.066 (almost)	*Pos*
Frontal calvaria	Sagittal split maxilla	0.052	*Pos*
	Frontobasal	0.000	*Pos*

	LeFort III	0.027	*Neg*
Frontal sinus	NOE	0.001	*Pos*
	Frontobasal	0.000	*Pos*
	Frontal calvaria	0.035	*Pos*
	Sagittal split maxilla	0.043	*Neg*
	Mandible	0.05	*Neg*
Panfacial fracture	Mandible	0.006	*Pos*
Polytrauma	LeFort I	0.003	*Pos*
	Mandible	0.006	*Pos*
	Frontobasal	0.000	*Pos*

Table 6 **Individual pure lateral midface fractures**

	amount	**& alveolar ridge**
Zygoma	105	2
Arch	30	
Orbital floor (blow out)	18	
Zygoma & arch	54	1
Zygoma & orbital floor	61	2
Arch & orbital floor	1	
Zygoma & arch & orbital floor	31	1
Anterior wall of maxillary sinus	1	
Total	301	6
Lateral midface plus supraorbital	20	
Lateral midface plus mandible	40	2
Lateral midface plus both	3	
Total	364	8

Table 7

Crosstabulation of zygoma and orbital floor fractures

		orbital floor fracture				Total
		right	left	bilateral	none	
zygoma fracture	right	74	2	2	101	179
	left	2	92	4	137	235
	bilateral	3	8	8	15	34
	none	15	21	8	99	143
Total		94	123	22	352	591

Table 8 **Injury mechanisms as causes of fractures**

	Average age	Total	Zygoma	Arch	Alveolar ridge	LeFort I	LeFort II	LeFort III	Sagittal maxill. split	Nose	NOE	Orbital floor	Frontobasal	Frontal calvaria	Frontal sinus	Mandible
Average age		39.4	39.1	37.6	33.8	41.7	41.5	38	28	42.5	35.1	36.1	38.2	35.1	39.2	37
Total	39.4	591	448	200	27	123	60	35	16	53	40	239	63	23	40	107
Assaults	36.6	91	68	31	3	11	3	2	2	11	1	42	2	0	0	10
Car crashes	33.3	84	65	32	8	30	18	10	1	13	3	40	10	5	5	29
Cyclists	44.2	80	63	20	2	16	8	9	4	7	11	28	13	4	4	14
Slips, trips, stumbles	52.1	61	45	12	0	8	3	0	0	3	1	14	0	0	0	7
Falls from height	44.3	58	41	19	1	18	7	3	0	6	5	20	12	6	6	11
Soccer players	32.1	38	30	17	0	3	2	0	0	0	0	16	0	1	1	1
Motorcyclists	34.4	30	25	9	2	9	4	4	1	2	2	15	8	3	3	10
Skiiers	39.2	28	24	13	1	4	3	1	1	0	0	12	1	0	0	2
Involuntary contacts	38.9	27	16	7	3	6	3	2	1	2	3	13	3	1	1	2
Equestrians	31.3	20	14	11	3	5	2	2	4	5	3	13	4	0	0	5
Pedestrians hit car	43.4	9	8	1	1	3	1	0	0	1	0	3	0	0	0	3
Inline skaters	41.5	7	7	3	0	0	0	0	0	0	0	2	0	0	0	0
Ice hockey players	26.9	6	4	4	0	0	0	0	0	0	0	2	0	0	0	1
Sledders	32.7	5	5	0	0	0	0	0	0	0	0	4	1	0	0	0
Compression trauma	40.4	5	4	2	0	2	3	1	0	0	3	3	2	1	1	2
Cow rel. accidents	40	4	3	3	0	1	0	0	0	0	0	0	0	0	0	1
Train rel. accidents	28.7	3	2	1	0	1	0	0	0	0	1	1	2	0	0	2
Basketball players	41.1	3	1	1	0	0	0	0	0	0	1	1	0	0	0	0
Gunshot injuries	28.3	3	2	2	2	0	0	0	1	0	2	2	1	1	0	2
Tram rel. accidents	37.8	2	2	2	0	0	0	0	0	0	0	0	0	0	0	1
Handball players	22.1	2	1	0	0	0	0	0	0	0	1	1	0	0	1	0
Ice skaters	63.3	3	3	1	1	0	0	0	0	0	0	1	0	0	0	0
Snowboarder	19.5	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0
Jet-skiier	35.2	1	1	1	0	0	0	0	0	0	0	1	0	0	0	1
Helicopter crash	29.2	1	0	0	0	1	1	0	0	0	1	0	1	1	0	0
Unknown	41	19	13	8	0	5	2	1	1	1	2	4	3	3	1	3

Involuntary contacts involve activities of everyday life or work in which the patient is hit by a plank of wood, a stone, a door etc.

Table 9 **Injury mechanism groups**

Traffic accidents	208	35.2%
Sports injuries	114	19.3%
Assault	91	15.4%
Slips	61	10.3%
Falls	58	9.8%
Involuntary contact	27	4.6%
Other	13	2.2%
Unknown	19	3.2%
Total	**591**	**100%**

Table 10 **Causes for accidents**

	Male		**Female**		**Total**	
Percent		%		%		%
Assault	77	17.2	14	9.8	91	15.4
Car passengers	56	17.2	28	19.6	84	14.2
Cyclists	59	12.5	21	14.7	80	13.5
Slips, stumbles. Etc.	35	7.8	26	18.2	61	10.3
Falls from height	46	10.3	12	8.4	58	9.8
Soccer	38	8.5	0	0	38	6.4
Motorcyclists	27	6	3	2.1	30	5.1
Skiers	20	4.5	8	5.6	28	4.7
Involuntary contacts	23	5.1	4	2.8	27	4.6
Equestrians	8	1.8	12	8.4	20	3.4
Pedestrians hit by car	5	1.1	4	2.8	9	1.5
Inline skaters	6	1.3	1	0.7	7	1.2
Ice-hockey	5	1.1	1	0.7	6	1
Sledders	4	0.9	1	0.7	5	0.8
Compression	5	1.1	0	0	5	0.8
Cow-related	4	0.9	0	0	4	0.7
Basketball	2	0.4	1	0.7	3	0.5
Train-related	2	0.4	1	0.7	3	0.5
Gunshots	3	0.7	0	0	3	0.5
Tram related	2	0.4	0	0	2	0.3
Handball	2	0.4	0	0	2	0.3
Ice-skaters	3	0.7	0	0	3	0.5
Snowboarders	1	0.2	0	0	1	0.2
Jet-skiiers	1	0.2	0	0	1	0.2
Helicopter crash	1	0.2	0	0	1	0.2
Unknown	13	2.9	6	4.2	19	3.2

Table 11 **Causes for accidents sorted by gender**

	Total		**Male**		**Female**	
Traffic accidents	208	35.2%	151	33.7%	57	39.9%
Sports injuries	114	19.3%	90	20.1%	24	16.8%
Assault	91	15.4%	77	17.2%	14	9.8%
Slips	61	10.3%	35	7.8%	26	18.2%
Falls	58	9.8%	46	10.3%	12	8.4%
Involuntary contact	27	4.6%	23	5.1%	4	2.7%à
Other	13	2.2%	13	2.9%	0	0%
Unknown	19	3.2%	13	2.9%	6	4.2%
Total	**591**	**100%**	**448**	**100%**	**143**	**100%**

Table 12 **Fractures as a function of gender**

	Total number	**Total percent**		**Zygoma**	**Arch**	**Alveolar ridge**	**LeFort I**	**LeFort II**	**LeFort III**	**Sagittal maxill. split**	**Nose**	**NOE**	**Orbital floor**	**Frontobasal**	**Frontal calvaria**	**Frontal sinus**	**Mandible**
male	448		**Nr**	341	159	20	94	47	28	10	37	34	179	57	20	36	74
		100	**%**	76.1	35.5	4.5	21	10.5	6.3	2.2	8.3	7.1	40	12.7	4.5	8	16.3
female	143		**Nr**	107	41	7	29	13	7	6	16	6	60	6	3	4	33
		100	**%**	74.8	28.7	4.9	20.3	9.1	4.9	4.2	11.2	4.2	42	4.2	2.1	2.8	23.1

Table 13 **Neurotrauma and injury crosstabulated**

	Total	Neurotrauma	
		Yes	No
Assaults	91	12	79
Car crashes	84	33	51
Cyclists	80	31	49
Slips, trips	61	8	53
Falls from height	58	19	39
Soccer players	38	2	36
Motorcyclists	30	13	17
Skiiers	28	4	24
Involuntary objects	27	3	24
Equestrians	20	6	14
Pedestrians hit by cars	9	4	5
Inline skaters	7	1	6
Ice-hockey players	6	1	5
Sledders	5	1	4
Compression trauma	5	2	3
Cow related accidents	4		4
Basketball players	3		3
Train related accidents	3	2	1
Gunshot injuries	3		3
Tram related accidents	2	1	1
Handball players	2		2
Ice-skaters	3	2	1
Snowboarder	1		1
Jet-skiier	1	1	
Helicopter crash	1	1	
Unknown	19	3	16
Total	591	150	441

Table 14 **Significant association in logistic regression**

Fracture	p-value
Nose	0.049
Mandible	0.023
Frontobasal	0.002
Frontal	0.009
Polytrauma	0.005

Table 15 **Polytrauma and injury crosstabulated**

	Total	Polytrauma	
		Yes	No
Assaults	91		91
Car crashes	84	24	60
Cyclists	80	2	78
Slips, trips	61		61
Falls from height	58	8	50
Soccer players	38		38
Motorcyclists	30	6	24
Skiiers	28	1	27
Involuntary objects	27		27
Equestrians	20		20
Pedestrians hit by cars	9		9
Inline skaters	7		7
Ice-hockey players	6		6
Sledders	5		5
Compression trauma	5		5
Cow related accidents	4		4
Basketball players	3		3
Train related accidents	3	2	1
Gunshot injuries	3		3
Tram related accidents	2		2
Handball players	2		2
Ice-skaters	3		3
Snowboarder	1		1
Jet-skiier	1		1
Helicopter crash	1		1
Unknown	19	2	17
Total	591	45	546

Figures

Figure 1 **591 midface trauma patients from 1991-2001**

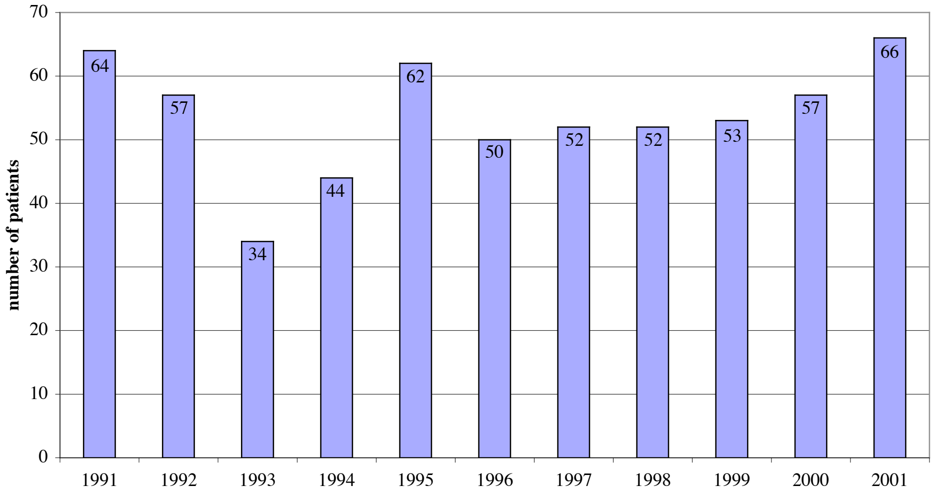


Figure 2 **Patients by months and years**

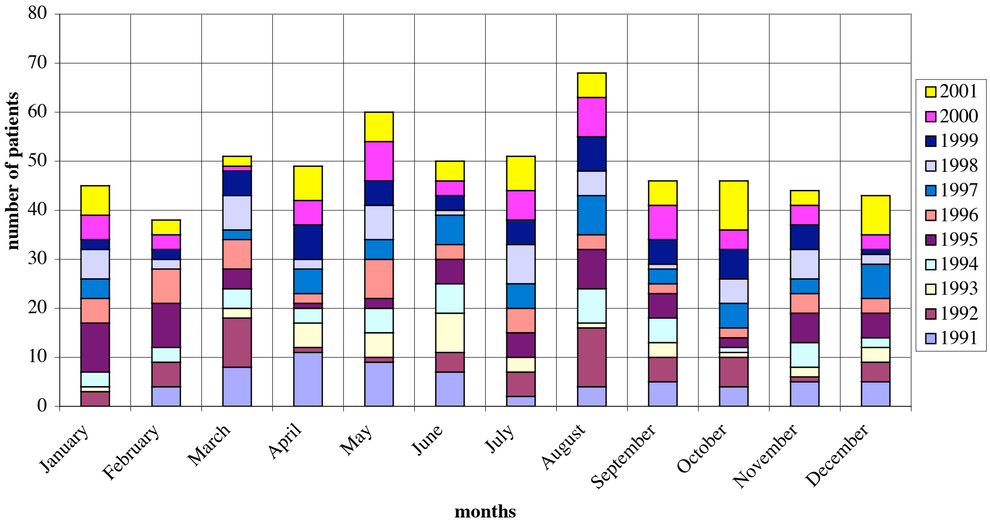


Figure 3 **107 patients with 188 mandibular fractures**

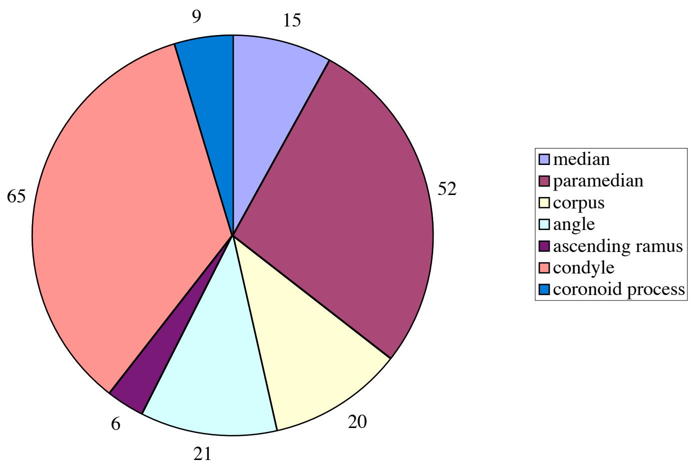


Figure 4 **Midface fracture groups**

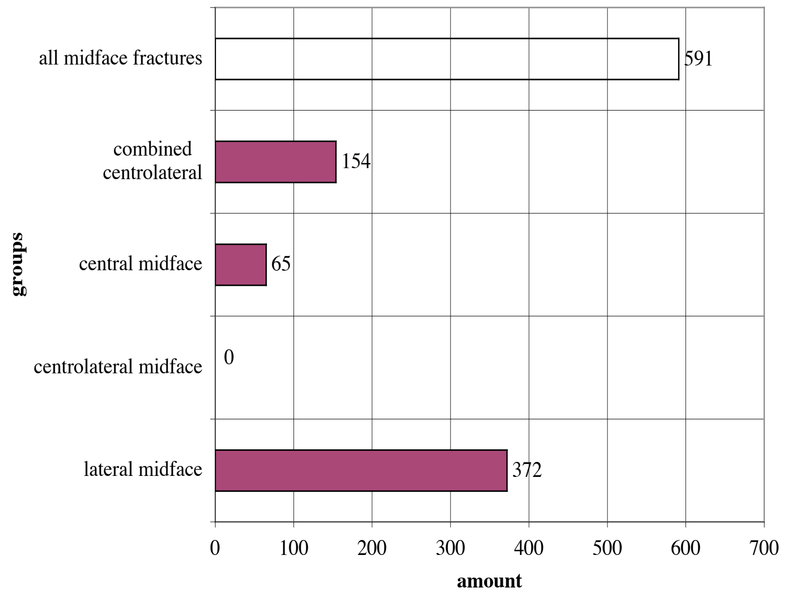


Figure 5 **173 patients with clearly defined LeFort fractures**

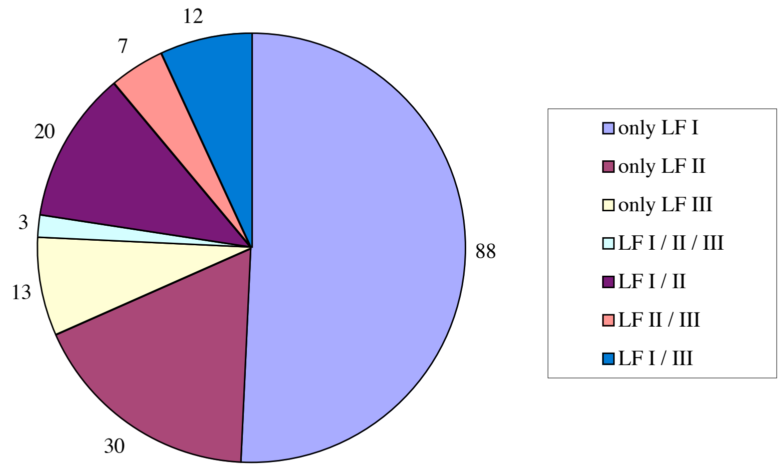


Figure 6 **Cyclists by months**

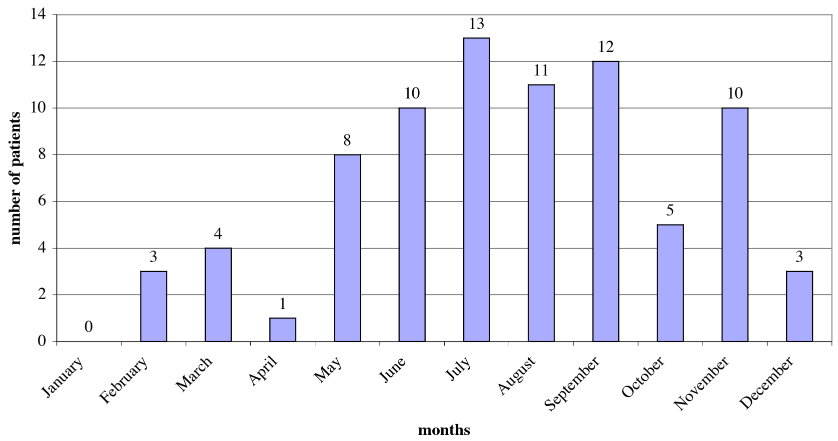


Figure 7 **Assaults by months**

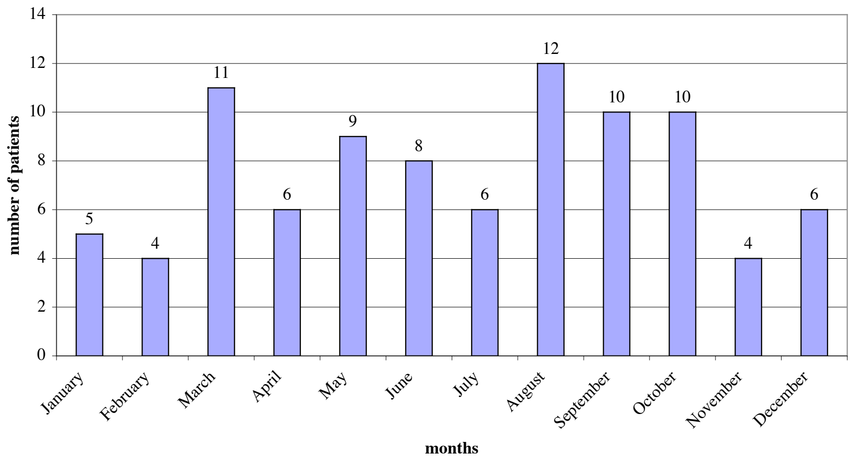


Figure 8 **Causes for accidents**

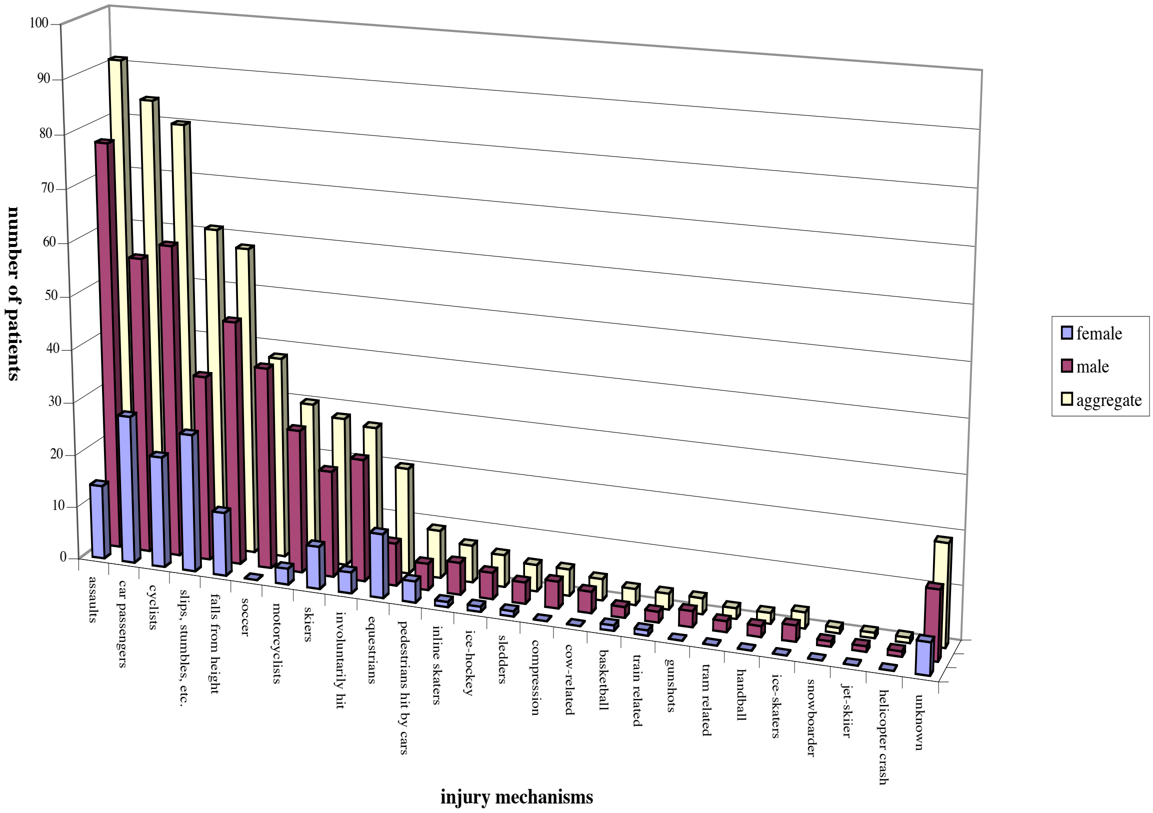


Figure 9 **Midface fracture patients counted in 5 year age-groups**

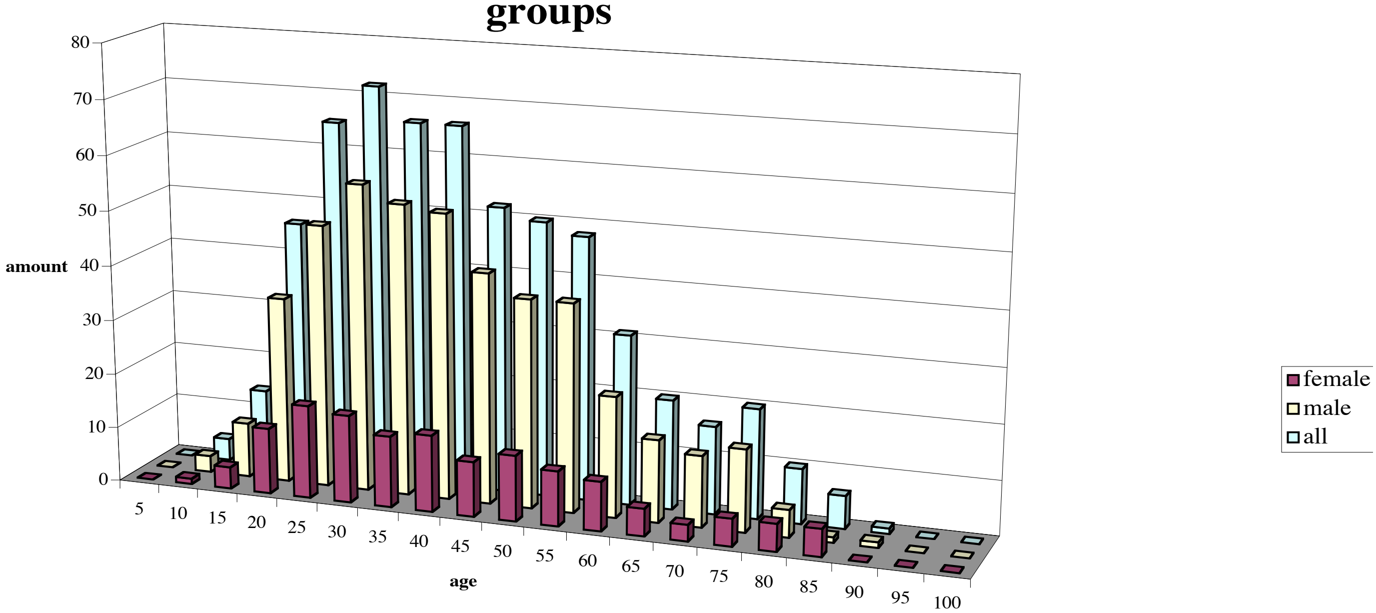


Figure 10 **Age-group to percent neurotrauma**

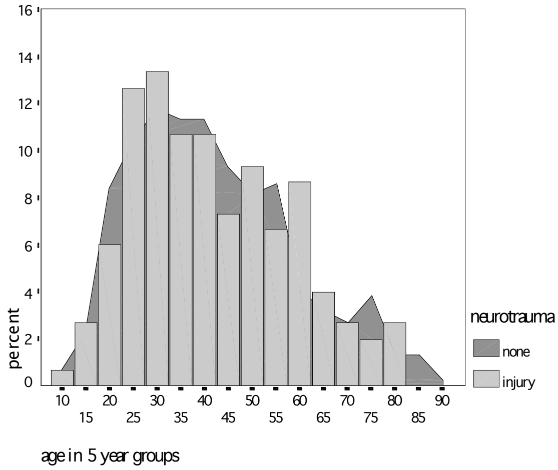


Figure 11 **Age-group to percent panfacial injury**

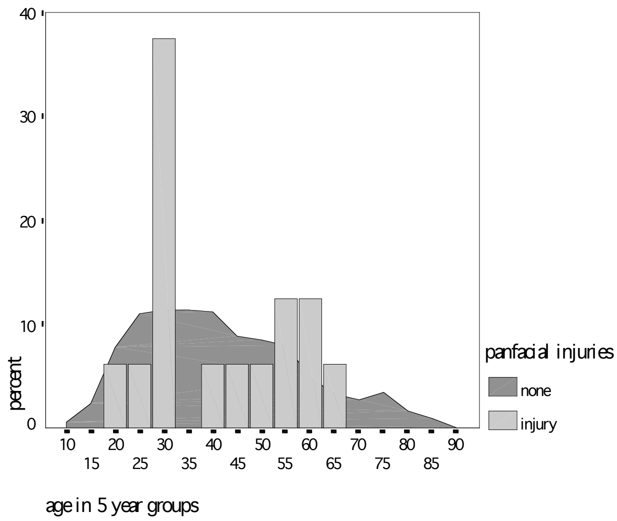
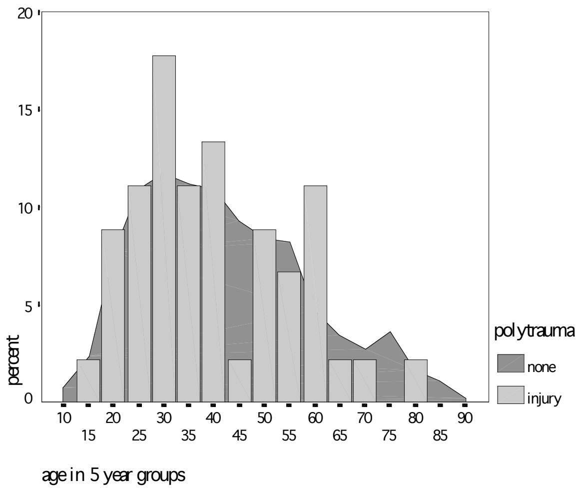


Figure 12 **Age-group to percent polytrauma**



References

1. University Hospital Zurich. Annual review. *http://www.usz.ch* (2005).
2. Shapiro, A. J., Johnson, R. M., Miller, S. F. & McCarthy, M. C. Facial fractures in a level I trauma centre: the importance of protective devices and alcohol abuse. *Injury* **32**, 353-356 (2001).
3. Gassner, R., Tuli, T., Hachl, O., Rudisch, A. & Ulmer, H. Cranio-maxillofacial trauma: a 10 year review of 9,543 cases with 21,067 injuries. *J Craniomaxillofac Surg* **31**, 51-61 (2003).
4. Schuknecht, B. & Graetz, K. Radiologic assessment of maxillofacial, mandibular, and skull base trauma. *Eur Radiol* **15**, 560-568 (2005).
5. Bataineh, A. B. Etiology and incidence of maxillofacial fractures in the north of Jordan. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* **86**, 31-35 (1998).
6. Aksoy, E., Unlu, E. & Sensoz, O. A retrospective study on epidemiology and treatment of maxillofacial fractures. *J Craniofac Surg* **13**, 772-775 (2002).
7. Lebeau, J. et al. [Facial injuries treated in the Grenoble University Hospital. Epidemiological analysis of 961 patients managed in one year]. *Rev Stomatol Chir Maxillofac* **107**, 23-29 (2006).
8. Bo, B., Gu, X. & Zhou, S. [An epidemiologic retrospective study of 1693 maxillofacial injuries]. *Hua Xi Kou Qiang Yi Xue Za Zhi* **16**, 56-58 (1998).
9. Hill, C. M., Burford, K., Martin, A. & Thomas, D. W. A one-year review of maxillofacial sports injuries treated at an accident and emergency department. *Br J Oral Maxillofac Surg* **36**, 44-47 (1998).
10. R, L. F. Etude expérimentale sur les fractures de la machoire supérieure. *Rev d Chir* **23**, 208-227, 360-379, 479-507 (1901).
11. Hausamen, J. E., Machtens, E. & Reuther, J. *Mund-, Kiefer- Und Gesichtschirurgie; Kirschnersche Allgemeine Und Spezielle Operationslehre* (Springer-Verlag, 1995).
12. Fonseca, R. J., Walker, R. & Betts, N. *Oral and Maxillofacial Trauma* (Saunders (W.B.) Co Ltd, 2005).
13. Rowe, N. L. First Aid Treatment, Diagnosis and Roentgenography of Maxillofacial Injuries. *J Oral Surg Anesth Hosp Dent Serv* **22**, 202-208 (1964).
14. Cooter, R. D. & David, D. J. Computer-based coding of fractures in the craniofacial region. *Br J Plast Surg* **42**, 17-26 (1989).

15. Greenberg, A. M. & Prein, J. Craniomaxillofacial Bone Surgery: Advanced Principles Using the AO/ASIF Technique. (2002).
16. Graetz, K. Dissertation: Eine neue Klassifikation zur Einteilung von Unterkieferfrakturen. (1985).
17. Buitrago-Tellez, C. H., Schilli, W., Bohnert, M., Alt, K. & Kimmig, M. A comprehensive classification of craniofacial fractures: postmortem and clinical studies with two- and three-dimensional computed tomography. *Injury* **33**, 651-668 (2002).
18. Fasola, A. O., Obiechina, A. E. & Arotiba, J. T. Concomitant injuries in 531 patients with maxillofacial fractures. *Afr J Med Med Sci* **31**, 101-105 (2002).
19. Kieser, J., Stephenson, S., Liston, P. N., Tong, D. C. & Langley, J. D. Serious facial fractures in New Zealand from 1979 to 1998. *Int J Oral Maxillofac Surg* **31**, 206-209 (2002).
20. Hogg, N. J., Stewart, T. C., Armstrong, J. E. & Girotti, M. J. Epidemiology of maxillofacial injuries at trauma hospitals in Ontario, Canada, between 1992 and 1997. *J Trauma* **49**, 425-432 (2000).
21. Maladiere, E., Bado, F., Meningaud, J. P., Guilbert, F. & Bertrand, J. C. Aetiology and incidence of facial fractures sustained during sports: a prospective study of 140 patients. *Int J Oral Maxillofac Surg* **30**, 291-295 (2001).
22. Kelley, P., Crawford, M., Higuera, S. & Hollier, L. H. Two hundred ninety-four consecutive facial fractures in an urban trauma center: lessons learned. *Plast Reconstr Surg* **116**, 42e-49e (2005).
23. Gassner, R., Hackl, W., Tuli, T. & Emshoff, R. Facial injuries in skiing. A retrospective study of 549 cases. *Sports Med* **27**, 127-134 (1999).
24. Gossman, D. G., Archer, S. M. & Arosarena, O. Management of frontal sinus fractures: a review of 96 cases. *Laryngoscope* **116**, 1357-1362 (2006).
25. Zapala, J., Saif, F., Moskala, M. & Krupa, M. [Results of multidisciplinary treatment of frontal sinus fractures.]. *Neurol Neurochir Pol* **40**, 376-385 (2006).
26. Haug, R. H., Van Sickels, J. E. & Jenkins, W. S. Demographics and treatment options for orbital roof fractures. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* **93**, 238-246 (2002).
27. Pappachan, B. & Alexander, M. Correlating facial fractures and cranial injuries. *J Oral Maxillofac Surg* **64**, 1023-1029 (2006).
28. Rhea, J. T. & Novelline, R. A. How to simplify the CT diagnosis of Le Fort fractures. *AJR Am J Roentgenol* **184**, 1700-1705 (2005).

29. Zachariades, N., Mezitis, M., Mourouzis, C., Papadakis, D. & Spanou, A. Fractures of the mandibular condyle: a review of 466 cases. Literature review, reflections on treatment and proposals. *J Craniomaxillofac Surg* **34**, 421-432 (2006).