Turun yliopisto
University of Turku

EPIDEMIOLOGY, MANAGEMENT AND OUTCOME OF FACIAL INJURIES

Ulla Perheentupa

TURUN YLIOPISTON JULKAISUJA – ANNALES UNIVERSITATIS TURKUENSIS
Sarja - ser. D osa - tom. 1118 | Medica - Odontologica | Turku 2014

University of Turku

Faculty of Medicine
Department of Otolaryngology-Head and Neck Surgery
Institute of Clinical Medicine
Doctoral Programme of Clinical Investigation (CLID), University of Turku and Turku University Hospital

Supervised by

Professor Antti Mäkitie, M.D., Ph.D.
Department of Otolaryngology-Head and Neck Surgery
University of Helsinki and Helsinki University Central Hospital, Finland

Adjunct professor Ilpo Kinnunen, M.D., Ph.D.
Department of Otolaryngology-Head and Neck Surgery
University of Turku and Turku University Hospital, Finland

Reviewed by

Adjunct professor Hanna Thorén, M.D., D.D.S., Ph.D.
Department of Oral and Maxillofacial Surgery
Helsinki University Central Hospital, Department of Oral and Maxillofacial Surgery, Institute of Dentistry, Helsinki University, Helsinki, Finland

Professor Markus Rautiainen, M.D., Ph.D.
Department of Otolaryngology-Head and Neck Surgery
University of Tampere and Tampere University Central Hospital, Finland

Opponent

Professor Christian Lindqvist, M.D., D.D.S., Ph.D.
Department of Oral and Maxillofacial Surgery
Helsinki University Central Hospital, Department of Oral and Maxillofacial Surgery, Institute of Dentistry, Helsinki University, Helsinki, Finland

The originality of this thesis has been checked in accordance with the University of Turku quality assurance system using the Turnitin OriginalityCheck service.

ISBN 978-951-29-5759-0 (PRINT)
ISBN 978-951-29-5760-6 (PDF)
ISSN 0355-9483
Painosalama Oy - Turku, Finland 2014

To my daughters Vilma and Emppu

ABSTRACT

Ulla Perheentupa
EPIDEMIOLOGY, MANAGEMENT AND OUTCOME OF FACIAL INJURIES

Department of Otolaryngology-Head and Neck Surgery, Institute of Clinical Medicine, Faculty of Medicine, University of Turku Doctoral Programme of Clinical Investigation (CLIDP), University of Turku and Turku University Hospital, Finland

Annales Universitatis Turkuensis, Medica-Odontologica, Turku, Finland, 2014

Dental injuries are common and the incidence of maxillofacial injuries has increased over the recent decades in Finland. Accidental injuries are the global leading cause of death among children over the age of one year and among adults under the age of 40 globally. Significant resources and costs are needed for the treatment of these patients. The prevention is the most economical way to reduce trauma rates and costs. For the prevention it is crucial to know the prevalences, incidences and risk factors related to injuries. To improve the quality of treatment, it is essential to explore the causes, trauma mechanisms and management of trauma. The above mentioned was the aim of this thesis.

With a large epidemiological cohort study (5737 participants) it was possible to estimate lifetime prevalence of and risk factors for dental trauma in general population (Study I). The prevalence of dental fractures was 43% and the prevalence of dental luxations and avulsions was 14%. Male gender, a history of previous non-dental injuries, mental distress, overweight and high alcohol consumption were positively associated with the occurrence of dental injuries. Study II was conducted to explore the differences in type and multiplicity of mandibular fractures in three different countries (Canada, Finland and Kuwait). This retrospective study showed that the differences in mandibular fracture multiplicity and location are based on different etiologies and demographic patterns. This data can be exploited for planning of measures to prevent traumatic facial fractures. The etiology, management and outcome of 63 pediatric skull base fracture (Study III) and 20 pediatric frontobasal fracture patients (Study IV) were explored. These retrospective studies showed that, both skull base fracture and frontobasal fracture are rare injuries in childhood and although intracranial injuries and morbidity are frequent, permanent neurological or neuropsychological deficits are infrequent. A systematic algorithm (Study V) for computer tomography (CT) image review was aimed at clinicians and radiologists to improve the assessment of patients with complex upper midface and cranial base trauma. The cohort study was cross sectional and data was collected in the Turku and Oulu University Hospitals. A novel image-reviewing algorithm was created to enhance the specificity of CT for the diagnosis of frontobasal fractures. The study showed that an image-viewing algorithm standardizes the frontobasal trauma detection procedure and leads to better control and assessment. The purpose of the retrospective subcranial craniotomy study (VI) was to review the types of frontobasal fractures and their management, complications and outcome when the fracture is approached subcranially. The subcranial approach appears to be successful and have a reasonably low complication rate. It may be recommended as the technique of choice in multiple and the most complicated frontal base fractures where the endoscopic endonasal approach is not feasible.

Keywords: facial injury, frontobasal, skull base, trauma

TIIVISTELMÄ

Ulla Perheentupa

KASVOVAMMOJEN EPIDEMIOLOGISET, HOIDOLLISET JA KUNTOUTUMISEEN LIITTYVÄT TEKIJÄT

Korva-, nenä- ja kurkkutautioppi, Kliininen laitos, Lääketieteellinen tiedekunta, Turun yliopiston kliininen tohtoriohjelma (TKT), Turun yliopisto ja Turun yliopistollinen keskussairaala, Turku, Suomi

Annales Universitatis Turkuensis, Medica-Odontologica, Turku, Suomi, 2014

Hammasvammat ovat yleisiä ja leukamurtumien määrä Suomessa on lisääntynyt viime vuosikymmeninä. Maailmanlaajuisesti erilaiset vammat ovat johtava kuolinsyy yli 1-vuotiailla lapsilla ja alle 40-vuotiailla aikuisilla. Vaikeasti vammautuneen potilaan hoito ja kuntoutus vie runsaasti myös terveydenhuollon resursseja ja tuo kustannuksia. Edullisinta vammojen hoitoa on niiden ennaltaehkäisy. Jotta ennaltaehkäisyä voidaan tehostaa, on tärkeä tutkia vammojen esiintyvyyksiä ja ilmaantuvuuksia, tunnistaa riskiryhmiä sekä ympäristöön ja henkilön riskikäyttäytymiseen liittyviä tekijöitä. Jotta hoitoa voidaan kehittää, on tärkeää selvittää myös kyseisten vammojen syitä, vammamekanismeja ja hoitokäytäntöjä, komplikaatiota sekä kuntoutumista. Se on ollut tämän väitöskirjatyön tavoite.

Osatyössä I selvitettiin laajan (5737 tutkittavaa) suomalaisen kohorttitutkimuksen perusteella hammasvammojen epidemiologiaa ja etiologisia tekijöitä. Hammasmurtumien esiintyvyys oli 43% ja hammasluksaatioiden ja avulsioiden esiintyvyys oli 14%. Tutkimuksen mukaan runsas hammasvammojen esiintyvyys oli yhteydessä aiempiin vammoihin, mielenterveysongelmiin, ylipainoon ja runsaaseen alkoholin käyttöön. Osatyössä II tarkasteltiin alaleukamurtumia kanadalaisessa, suomalaisessa ja kuwaitilaisessa aineistossa. Tutkimus toi esiin eroja maiden välillä ja pyrki osoittamaan mihin tekijöihin traumojen ennaltaehkäisevässä suunnittelussa tulisi kiinnittää huomiota. Osatöissä III ja IV selvitettiin lasten ja nuorten vakavien kasvovammojen ja kallonpohjan- sekä frontobasaalimurtumien määrää, vammamekanismeja, hoitomenetelmiä, hoitotuloksia sekä päänvammasta kuntoutumista ja myöhäiskomplikaatioita. Keskeisimpiä havaintoja näissä harvinaisissa vammoissa oli, että aivovammat ja pitkäkestoinen vajaakuntoisuus vamman jälkeen ovat yleisiä mutta valtaosalle ei kuitenkaan jää pysyviä neurologisia tai neuropsykologisia ongelmia. Osatyössä V systemaattisen algoritmin tarkoitus oli helpottaa kliinikon ja radiologin diagnostiikkaa etukallonpohjan ja yläkasvojen trauma TT-kuvia analysoitaessa. Aineistoksi tähän poikittaiskohorttitutkimukseen kerättiin Varsinais-Suomen ja Pohjois-Pohjanmaan Sairaanhoitopiirien alueen frontobasaalimurtumapotilaiden radiologinen kuvamateriaali. Sen avulla luotiin sabloona kliinikolle anteriorisen kallonpohjan ja yläkasvojen systemaattiselle analysoinnille helpottamaan diagnostiikkaa. Traumadefektin diagnosointi tarkasti heti alkuvaiheessa on edellytys parhaan hoitolinjan valinnan kannalta (kirurginen vs. konservatiivinen hoitolinja) ja tutkimuksen perusteella systemaattinen algoritmi lisäsi tarkkuutta diagnostiikassa. Osatyössä VI selvitettiin frontobasaalimurtumien operatiivista hoitoa subkraniaalisella kraniotomialla VSSHP:ssä huomioiden potilaiden komplikaatiot ja kuntoutuminen. Vaikeita komplikaatioita oli vähän ja päätelmänä oli, että subkraniaalinen kraniotomia on edelleen hyvä ja käyttökelpoinen kirurginen tekniikka pirstaleisten, vaikeiden murtumien hoidossa jolloin endoskooppista endonasaalista tekniikkaa ei voida käyttää.

Avainsanat: kasvovamma, frontobasaali, kallonpohja, trauma

TABLE OF CONTENTS

ABBREVIATIONS

BMI	body mass index
CAS	computer-assisted surgery
CCF	carotid-cavernous-fistula
CI	confidence interval
CSF	cerebrospinal fluid
CT	computer tomography
CTA	computed tomography angiography
GCS	Glasgow Coma Scale
GOS	Glasgow Outcome Scale
HSCL-25	Hopkins Symptom Check List (25 questions)
ICD-10	International Classification of Disease, 10^{th} edition
ICH	intracranial hemorrhage
ICU	intensive care unit
MDCT	multidetector helical computed tomography
MPR	multiplanar reformation
MRI	magnetic resonance imaging
NFOT	nasofrontal outflow track
NOE	naso-orbito-ethmoidal fracture
ORIF	open reduction and internal fixation
RR	risk ratio
RTA	road traffic accident
SAH	subarachnoidal hemorrhage
SDH	subdural hemorrhage
TBI	traumatic brain injury

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following articles, which will be referred to in the text by the Roman numerals I – VI.

I Perheentupa U, Laukkanen P, Veijola J, Joukamaa M, Järvelin MR, Laitinen J, Oikarinen K. Increased life-time prevalence of dental trauma is associated with previous non-dental injuries, mental distress and high alcohol consumption. Dent Traumatol 2001; 17: 10-16.

II Oikarinen K, Thalib L, Sandor GK, Schutz P, Clokie CM, Safar S, Meisami T, Perheentupa U. Differences in the location and multiplicity of mandibular fractures in Kuwait, Canada and Finland during the 1990's. Med Princ Pract 2005; 14: 10-15.

III Perheentupa U, Kinnunen I, Grénman R, Aitasalo K, Mäkitie A. Management and outcome of pediatric skull base fractures. Int J Ped Otorhinolaryngol 2010; 74: 1245-1250.

IV Perheentupa U, Kinnunen I, Grénman R, Aitasalo K, Karhu JO, Mäkitie A. Post-traumatic morbidity is frequent in children with frontobasilar fractures. Int J Ped Otorhinolaryngol 2012; 76: 670-674.

V Perheentupa U, Mäkitie AA, Karhu JO, Koivunen P, Blanco Sequeiros R, Kinnunen I. Frontobasilar fractures: a proposal for image reviewing algorithm. J Craniomaxillofac Surg 2014 Feb 11. pii: S1010-5182(13)00148-0. doi: 10.1016/j.jcms.2013.05.018. (in press)

VI Perheentupa U, Mäkitie AA, Kinnunen I. Subcranial craniotomy approach for frontobasal fracture correction. J Craniomaxillofac Surg 2014 Apr 3. pii: S1010-5182(14)00108-5. doi: 10.1016/j.jcms.2014.03.028. (in press)

1 INTRODUCTION

Traumatic accidental injuries are the leading causes of death in the first four decades of life and they cause a greater loss of working years than cardiac diseases and malignancies together (Gassner et al.,2003, http://www.cdc.gov/nchs/fastats/lcod.htm). Treatment of injuries engages significant health care resources and adjunctive costs (Allareddy et al., 2011). The World Health Organization (WHO) predicts that the number of trauma victims will rise (World Health Organization 2005). Trauma is clearly a major health issue.

The incidence of maxillofacial trauma has increased over the recent years in several countries (Kontio et al., 2005, Ravindran and Ravindran Nair 2011, Lee 2012). The highest lifetime incidence of maxillofacial trauma is between the third and fourth decades of life (Bakardjiev and Pechalova 2007, Eggensperger et al., 2007, Subhashraj et al., 2007, Lieger et al., 2009, De Matos et al., 2010, Thorén et al., 2010, Ravindran and Ravindran Nair 2011). Maxillofacial fractures in children under the age of 10 are uncommon (Cheema and Amin, 2006, Kadkhodaie 2006), while three fourths of dental injuries occur among children and teenagers (Eilert-Sörensen 1997).

Skull vault fractures are the most common craniofacial injury in early childhood (McGraw et al., 1990, Lallier et al., 1999, Chan et al., 2004, Eggensperger Wymann et al., 2008). Male gender predominates (Oikarinen et al., 2004, Bakardjiev and Pechalova 2007, Simsek et al., 2007, Borrman et al., 2009, Lieger et al. 2009, Lee 2009, De Matos et al., 2010, Lee et al., 2010, Allareddy et al., 2011). There is not agreement on the frequency of the individual types of facial fractures in literature: According to some studies, mandibular fractures are the most common facial fractures (Bakardjiev and Pechalova 2007, Lee 2009, Thoren et al., 2009, van Hout et al., 2013) and in some studies nasal (Hwang et al., 2010, Allareddy et al., 2011) and midfacial fractures (Subhashraj et al., 2007). In the developing countries the causes of maxillofacial fractures are often road traffic accidents (RTA's) (Oikarinen et al., 2004, Sakr et al., 2004, Ravindran and Ravindran Nair 2011) and in the developed countries the violence seems to be the leading cause (Oikarinen et al., 2004, Kontio et al., 2005, Simsek et al., 2007, Lee 2009, Allareddy et al., 2011) followed by falls and sports injuries (Gassner et al., 2003, De Matos et al., 2010). The force required to fracture the thick frontal bone is two to three times higher than the force required to fracture any other facial bone (Nahum 1975) and this explains why intracranial injuries are common (Bell and Chen, 2010). RTA's cause often such high-energy impact and hence frontobasilar fractures are often also associated with additional facial fractures and multisystem injuries (Bell et al., 2004, Meco and Oberascher 2004, Bell and Chen, 2010). Consequently, skull base and frontobasilar fractures are potentially fatal and head injury is one of the causes of death also of children (Jagannathan et al., 2007). Dental injuries are seldom fatal but they not only cause subjective suffering and economic costs but may also change the facial appearance of the patient and cause psychological burden (Cortes et al., 2002).

Prevention is the most economic way to reduce trauma rates and related costs. Effective prevention requires that the risk factors related to traumatic injuries are identified (Chrcanovic 2012). Understanding the mechanisms resulting in trauma e.g., high-risk behaviour, and identifying these risk groups prone to facial injuries will ideally aid health care professionals to establish appropriate methods of intervention. Epidemiological information is important for designing preventive public health programs and for funding them. The high incidence of assault-related injuries warrants awareness of cultural and socioeconomical factors. Social programs aimed at enhancing tolerance in the community and preventing and reducing violence should be encouraged.

Although the majority of children with severe head injury have a good long-term functional outcome (Thomale et al., 2010), young people still face many years of disability due to traumatic brain injury (TBI). The age of the patient affects outcome following TBI and children have generally a better outcome than adults (Dhandapani et al., 2012). Careful evaluation of the management and outcome of skull base and frontobasilar fractures is essential for improvement of the quality of treatment. In head trauma diagnostics the cranial-CT is the golden standard (Novelline, 2004, Provenzale, 2010, Kubal, 2012). A systematic review of CT images is crucial for identification of all relevant structures and for a correct assessment of the injuries of the patient and for correct treatment, i.e. conservative or operative treatment. Transnasal endoscopic techniques have recently gained popularity for the operative treatment of frontobasilar fractures, although the open approach still is an acceptable treatment option for multiple fractures and fractures involving nerve lesions (Kirtane et al., 2005, Scholsem et al., 2008, Liu, 2010).

This series of studies was conducted to explore the association between some epidemiological factors and the risk of dental injuries in the general Finnish population and to compare the type and location of mandibular fractures in different countries (Canada, Finland and Kuwait). The management and outcome of pediatric patients with skull base and frontobasilar fractures was retrospectively evaluated in a single academic tertiary referral center. The accuracy of computerized tomography images in revealing all fracture sites and for predicting morbidity was assessed to characterize the importance of imaging for diagnosis. Subcranial craniotomy as surgical treatment of frontobasilar fractures was evaluated to describe the indications, patient selection, outcome and complications of this procedure.

2 REVIEW OF THE LITERATURE

2.1 Epidemiology of dental, mandibular and midfacial injuries

2.1.1 Epidemiology of dental injuries

Of all dental injuries 75% occur during childhood and adolescence (Eilert-Sörensen 1997). The incidence of dental injuries in childhood varies from 1% to 4% (Andreasen et al., 2007). The highest incidence of anterior dental trauma is from age seven to twelve (Glendor et al., 1996, Diaz et al., 2010). Among children, the prevalence of dental injuries varies from 4% to 35% (Todd and Dodd 1985, Oikarinen et al., 1987, Borssen et al., 1997, Navabazam and Farahani 2010). According to population based studies the prevalence of traumatic dental injuries varies from 4% to 59% (Andreasen et al., 2007). In general, the prevalence of dental injuries to the primary dentition is approximately 30% and the permanent dentition 20% (Andreasen and Ravn, 1972, Glendor et al., 2007). This wide variation is partly explained by the lack of standardized epidemiological protocols making comparison between countries difficult. Cultural, socioeconomic and behavioral variations explain also some of the variation (Andreasen et al., 2007).

There is a large number of studies on dental injuries in children and adoslescents but less on the prevalence of and risk factors for dental injuries in the general population. The predisposing factors are divided into oral factors e.g. incisor overjet, enviromental factors e.g., dangerous enviromental conditions and low income and deprivation and behavioral factors e.g., risk-taking personality, mental distress, high alcohol consumption, obesity, attention-deficit-hyperactivity disorder (ADHD) and certain conditions, like cerebral palsy (Petti and Tarsitani 1996, Marcennes and Murray 2001, Holan et al., 2005, Sabuncuoglu et al., 2005, Soriano et al., 2007, Glendor et al., 2007, Wright et al., 2007, Glendor 2009, Hecova et al., 2010). Well known causes for dental injuries are traffic accidents or collisions, accidental falls, being struck by an object, violence and sports (Hecova et.al, 2010, Glendor et al., 2007, Wright et al., 2007). The etiological factors vary by age; in childhood falls are common, later sports-related accidents become common and in adolescence and adulthood the violence and traffic accidents are the leading causes of trauma (Glendor 2009, Guedes 2010). Generally, falls, activities of daily living and sports are the most frequent causes for dental trauma in children (Gassner et al., 2004, Shayegan et al., 2007).

Crown fractures are the most common type of dental injury to the permanent dentition, followed by concussion and subluxation (Diaz et al., 2010, Lauridsen et al., 2012). Subluxation is the most common injury to the primary dentition (38.6%) followed by avulsion (16.6%) (Diaz et al., 2010). In studies not specifying whether the injury affected primary or permanent dentition, subluxation and luxation were the most common type of dental injury followed by crown fractures (Gassner et al., 2003, Gassner et al., 2004, Shayegan et al., 2007). The maxillary incisors are the most frequently injured teeth (Alonge et al., 2001, Shayegan et al., 2007, Hecova et al., 2010). In the pediatric population, up to 96% of the fractured teeth involve the maxillary incisors (Alonge et al., 2001). Approximately half of the patients with facial injury have simultaneously a dentoalveolar injury (Gassner et al., 1999, Gassner et al., 2003), among children even more (76%) (Gassner et al., 2004). In a study on associated dental injuries among patients with facial fractures, the most common injury type was dental fracture (48%) followed by subluxation or luxation (25%). The overall prevalence of dental trauma among facial fracture patients was 16%. Predictors of dental injuries were road traffic accidents and mandibular fractures (Thorén et al., 2010).

Dental injuries could be largely prevented, if the risk factors were better understood. Mouthguards and helmets for face protection are often mandatory in some high-risk sports like icehockey, rugby, inline skating, American football, mountainbiking and skateboarding. The use of protective devices, like helmets during cycling could reduce the risk for facial injuries by 65% (Thompson et al., 2009). According to a Norwegian prospective study involving 7-18 year old children, one third of traumatic dental injuries could be prevented, according to the treating dentists (Skaare and Jacobsen, 2003). By changing the attitudes to bullying, violent behavior and consumption of alcohol the incidence of the most severe dental injuries could be reduced. Further actions, like safer playgrounds or personal and social education could also constitute important preventive measures (Glendor and Andersson, 2007). Nevertheless, there is no single risk factor for dental trauma but there are many; there is an interplay between oral, enviromental and behavioral factors and injuries are often unavoidable. There is no evidence-based data on the effect of prevention of dental injuries (Sigurdsson 2013).

2.1.2 Epidemiology of mandibular fractures

The mandibular fracture is a common facial fracture with an incidence of twice that of midfacial fractures (Vetter et al., 1991, Bakardjiev and Pechalova 2007, Lee 2009, De Matos et al., 2010). According to some studies, mandibular fractures are the most common facial fractures (Bakardjiev and Pechalova 2007, Lee 2009, Thoren et al., 2009, van Hout et al., 2013), whereas other studies have reported that nasal bone (Hwang et al., 2010, Allareddy et al., 2011) and midfacial (Subhashraj et al., 2007) fractures are the most common. The percentage of mandibular fractures varies from 24% to 73% of all facial fractures (Kelly et al., 1975, Gassner et al., 2003, Motamedi 2003, Lieger et al., 2009). The pattern of facial fractures varies from country to country and the variation is partly explained by different cultural, enviromental, social and economic circumstances (Ellis et al., 1985, Gassner et al., 2003, Oikarinen et al., 2004, Basileiro et al., 2006).

RTA's and violence are the leading causes for mandibular and facial fractures, followed by falls the importance of which varies from study to study (Patrocinio et al., 2005, Kadkhodaie 2006, Sakr et al., 2006, Bakardjiev and Pechalova 2007, Bormann et al., 2009, Lee 2009, De Matos et al., 2010, Allareddy et al., 2011). The causes for mandibular fractures have changed over the past three decades (Motamedi 2003). In the developing countries the RTA's are often the leading cause (Oikarinen et al., 2004, Sakr et al., 2004, Ravindran and Ravindran Nair 2011) whereas in the developed countries assults (Oikarinen et al., 2004, Kontio et al., 2005, Simsek et al., 2007, Lee 2009, Allareddy et al., 2011), followed by sports injuries (Gassner et al., 2003) seem to be the leading causes for mandibular and midfacial fractures. Traffic laws are statutory and strict and they are respected more in developed countries (Sakr et al., 2006). In the developing countries there is an ongoing migration from the rural to the busy urban environment where traffic volumes have increased rapidly and the infrastucture (e.g., road construction) is weak. Seat belts or helmets are not so widely accepted and legislative measures such as not driving under the influence of alcohol are not necessaryly compulsory – factors all contributing to a high incidence of RTA-associated injuries (Ravindran and Ravindran Nair 2011). High alcohol consumption is associated with maxillofacial injuries caused by assults (Oikarinen et al., 2004, Buchanan et al., 2005, Ravindran and Ravindran Nair 2011). In a pediatric population the RTA's and falls are the most common causes for mandibular fractures (Imahara et al., 2011).

The site of the fracture is related to the etiology of the injury and the location of the most common injury varies. According to some studies, the most common location of mandible fractures is the condyle, followed by mandibular body fractures; these fractures are often due to RTA's and falls (De Matos et al., 2010). Another study (Zix et al., 2011) quotes condylar fractures followed by mandibular symphysis and angle due to RTA and sports injuries as the leading injury sites. Other studies, again, have found the symphysis (Patrocinio et al., 2005, Imahara et al., 2011) or the angle of mandible followed by the parasymphysis to be the most common injury sites (Rashid et al., 2013). Parasymhysis fracture was the most common (31%) type of mandibular fracture in a study of 2748 patients with maxillofacial injuries (Subhashraj et al., 2007).

There is a relationship between etiology and fracture site; angular fractures are often caused by assaults (Ellis et al., 1985, Simsek et al., 2007, Borrman et al., 2009, Rashid et al., 2013), whereas condylar and parasymhyseal fractures are often caused by RTA's and falls (Zix et al., 2011). In general, mandibular fractures are often multifactorial and the mechanism of injury varies. They are caused by low-energy impact, while midfacial and upperfacial fractures are related to high-energy impact (Qudah et al., 2005). Male gender predominates in studies of facial fractures (Da Silva et al., 2004, Oikarinen et al., 2004, Patrocinio et al., 2005, Bakardjiev and Pechalova 2007, Simsek et al., 2007, Borrman et al., 2009, Lee 2009, Lieger et al. 2009, De Matos et al., 2010, Lee et al., 2010, Thorén et al., 2010, Centers for Disease Control and Prevention 2011, Allareddy et al., 2011).

2.1.3 Epidemiology of midfacial fractures

The incidence of maxillofacial fractures has increased in recent years (Kontio et al., 2005, Lee 2012). Midfacial fractures occur often in combination with synchronous trauma and this causes morbidity and requires significant resources - expenses to health care system are high (Centers for Disease Control and Prevention 2011). The most commonly fractured site in midface is the area of the zygomatic bone and arch (Subhashraj et al., 2007, Naveen Shankar et al., 2012), and the orbital floor (Kraft et al., 2012). Among middle third fractures of the face, the zygomaticomaxillary fractures are the most common, followed by Le Fort II and Le Fort I fractures (Subhashraj et al., 2007). The frequency of midfacial fractures and associated skull base fractures is no less than 62% (Hardt and Kuttenberger, 2010). Over 25-50% of facial fracture patients have syncronous trauma to their limbs, brain, chest, spine or abdomen. The incidence of coinciding trauma depends on the trauma mechanism; high-energy impact increases the risk of associated injuries (Follmar et al, 2007, Mithani et al., 2009, Thorén et al., 2010). Six percent of facial fracture patients require immediate life-saving procedures like craniotomy due to intracerebral injury, airway intervention (endotracheal intubation, tracheostomy or cricothyrotomy) due to airway compromise or thoracotomy following pulmonary trauma. Two percent have hemorrhagic shock (Tung et al., 2000). The most common associated injury is cerebral injury (Tung et al., 2000, Follmar et al., 2007, Mithani et al., 2009), but in a study of 401 patients the most common associated trauma was injury to extremities, followed by cerebral injury (Thorén et al., 2010). The incidence of associated spinal injuries varies from 2.7% to 9.6% (Mithani et al., 2009, Thorén et al., 2010). Upper spinal injuries are associated with mandibular fractures as a consequence of predictable vectors of force divergency (Ardekian et al., 1997, Mithani et al., 2009). Energy causing a mandibular fracture may shift downwards causing spinal injury. There may also be an association between bilateral midfacial injuries and spinal injuries (Mithani et al., 2009). RTA's generate often high-energy impact. However, the likelihood of RTA-induced facial fracture is decreasing (McMullin et al., 2009), probably due to improved restraints, airbags and improved design of cars with advanced safety technology. Neurotrauma occurs more often (19%) to cyclist compared to motorcyclists (4%) who wear compulsory helmets which, prevent or decrease the intracranial impact of accidents (van Hout et al., 2013). Nevertheless, TBI associated with midfacial fractures of motocycle accident victims is associated with an unfavorable outcome (Lee et al., 2012).

According to the literature, the highest incidence of maxillofacial fractures is between the ages of 21 and 30 (Hogg et al., 2000, Gassner et al., 2003, Eggensperger et al., 2007, Subhashraj et al., 2007, De Matos et al., 2010, Thorén et al., 2010, Ravindran and Ravindran Nair 2011) and between the ages of 31 and 40 (Pappachan et al., 2006, Bakardjiev and Pechalova 2007, Lieger et al., 2009). Approximately 15% of patients are under the influence of alcohol or drugs (van Hout et al., 2013). The incidence of facial trauma among the elderly has increased, claimedly due to a more active lifestyle in this age group (Chrcanovic et al., 2010). Facial injuries following falls are frequent among children under the age of five, elderly people (over 75 years) and females (Bulut et al., 2006, Lee 2009, Roccia et al., 2009). Facial injuries are rather uncommon

(4.6%) among traumatically injured children aged 0 to 18 years but they are associated with a 63% higher mortality rate compared to injured children without facial fractures (Imahara et al., 2008). Mortality is attributed to a higher intracranial injury rate associated with facial fractures. Some 3% to 15% of all facial fractures occur in the pediatric population (Kontio et al., 2005, Vyas et al., 2008). The percentage of facial fractures increases with age. Especially cranial but also midfacial injuries are more common in infants and toddlers, while mandibular injuries are more common in adoslescents (Gassner et al., 2003, Imahara et al., 2008). The relative proportion of midfacial fractures compared to mandibular fractures has increased recently in pediatric population, probably as a consequence of improved imaging for diagnostics rather than a real change in the occurrence of these traumas (Thorén et al., 2009).

A discussion of the current trends in the management and operative treatment of mandibular and midfacial fractures is beyond the scope of this review. The emphasis lies on the epidemiology of facial injuries and the epidemiology, management and outcome of frontobasilar fractures. There are, in general, in addition to the golden standard in facial fracture repair such as the use of titanium fixation material, various plating systems available e.g. resorbable plates, locking plates, prebent plates for mandibular and orbital floor reconstruction, customized implants and 3D plates for the reconstruction of mandibular fractures (Meslemani and Kellman, 2012, Sadhwani and Anchlia, 2013, Van Bakelen et al., 2013). Endoscopic techniques have also come into use, especially for the reduction and fixation of non-comminuted mandibular subcondylar fractures (Meslemani and Kellman, 2012). Intraoperative CT imaging has made it possible to assess the outcome of reduction and fixation of various fractures estimated during the operation (Meslemani and Kellman, 2012). Prototyping techniques and computer-assisted surgery (CAS) are further recent advances in craniomaxillofacial surgery (Poukens et al., 2003, Li et al., 2009).

2.2 Frontobasilar fractures

2.2.1 Epidemiology of frontobasilar and skull base fractures

Upper facial fractures include the frontal sinus, skull base and cranial vault and comprise 4% to 14% of all cranio-maxillofacial fractures (Gassner et al., 2003, Hohlriedel et al., 2003, Cunningham and Haugh 2004, Bell et al., 2007). One fourth of all head injured patients fracture the anterior base of their skull (Rocchi et al., 2005). Most (70%) skull base fractures occur in the anterior skull base, followed by the middle central skull base (20%) and the middle skull base in combination with the posterior fossa (www.aofoundation.org).

Frontobasilar fractures constitute complex fractures of the anterior skull and they are often associated with lifethreatening brain injuries (Burstein et al., 1997, Mithani et al., 2009, Schaller et al., 2012). Anatomically, the frontobasilar area consists of the upper midface and the anterior skull base, i.e., the orbital roofs, posterior wall of frontal sinus, naso-ethmoidal complex, cribriform plate and walls of sphenoid sinus. The wider term is fracture of the skull base, which by definition involves several bones such as the temporal, occipital, sphenoidal and spheno-ethmoidal complex and the orbital portion of the frontal bone. The clinical signs of skull base fracture include retroauricular with or without periorbital hematoma, hemotympanum, cerebrospinal fluid (CSF) otorrhea or rhinorrhea. Petrous bone fractures may cause CSF leak through ear (otorrhea) and facial nerve palsies (Samii et al., 2002). Middle and posterior skull base fractures consist mainly of petrous bone fractures.

Fractures to the frontal base area are rare and usually caused by high-energy trauma (Burstein et al., 1997, Thoren et al., 2010, Calderoni et al., 2011, Naveen Shankar et al., 2012). Experimentally, the force needed to fracture the thick frontal bone is two to three times greater than the force needed to fracture any other facial bone (Nahum, 1975). The required amount of mass to fracture the thick frontal bone is approximately 363 to 998 kilograms (Tan and Bailey, 2006). Following such a high-energy impact the intracranial injuries are common. The frequency of intracranial injuries associated with skull base fractures varies from 36% to 64% (Burstein et al., 1997, Whatley et al., 2005). Closed head injuries, cranial vault fractures and skull base fractures are risk factors for traumatic intracranial hemorrhages that require surgical intervention (Hohlriedel et al., 2003). The impact to the upper midface disseminates often force to adjacent soft tisues and the midface and this results in soft tissue injuries and midfacial fractures (Rontal 2008). Most of the frontobasilar fracture patients (84%) have concomitant midfacial fractures and cranial nerve injuries (24%). CSF leaks (5% to 33%) are common as well (Beckhardt et al., 1991, Meco and Oberascher 2004, Bell and Chen 2010).

The dura lies in close proximity to the cribriform plate and dural tears are often associated with frontobasilar fractures (Parmar et al., 2009). Every third (33%) anterior skull base fracture is complicated by CSF leakage and dural tear, but only 6% of temporal fractures (Meco and Oberascher 2004). In general, fractures of the anterior cranial fossa are more commonly associated with dural tear and CSF leakage than fractures of the middle cranial fossa (Mendizapal et al., 1992, Friedman et al., 2001). Up to 56% to 80% of CSF leakages are due to trauma (Banks et al., 2009, Prosser et al., 2011). The most common sites for traumatic CSF leak are the frontal sinus (31%) and the sphenoid sinus (31 %) followed by the ethmoid sinus (15%) and cribriform plate (8%) (Banks et al. (2009). Eighty percent of CSF leaks occur within two days after the trauma and nearly all (95%) within three months after the injury (Schlosser and Bolger, 2004). CSF leaks due to anterior cranial base defects cease spontaneously in 25% of the patients and otorrhea in 60-75% (Yilmazlar et al., 2006, Lloyd et al., 2008). Since up to one third of patients with skull base fractures have CSF leakage (Beckhardt et al., 1991, Meco and Oberascher, 2004) 28% to 32% of these patients will develop meningitis (Friedman et al., 2001, Daudia et al., 2007), which is associated with a 4% mortality rate (Eljamel and Foy 1990). The incidence of meningitis following head injury is around 1.4% (Baltas et al., 1994). Most patients with meningitis complicating closed head trauma have a skull base fracture (Baltas et al., 1994, Van de Beek et al., 2010). The risk of infection of no less than 25% is related to the anatomical fact that there is a connection between the subarachnoid space and the sinonasal cavity. The duration between injury and onset of meningitis is approximately 11 days (Baltas et al., 1994, Choi et al., 1996). CSF leakage associates with frontobasilar fractures as often as with meningitis (8.3 % to 8.6 %, respectively) (Manson et al., 2009).

Anterior skull base injuries cause also injuries to the olfactory, optic, oculomotor, trochlear and abducens nerves, the contents of orbita, the carotid canal and the internal carotid artery. Injuries to the internal carotid artery may eventually result in carotid-cavernous fistula (CCF) (Samii et al., 2002).

2.2.2 Diagnostics of frontobasilar fractures

Clinical diagnostics

Frontobasilar fractures are associated with high morbidity and even mortality. Early evaluation of these fractures by examining an injured patient is essential for identifying and preventing complications, such as CSF leakage with a risk for meningitis, vascular injuries, compression of the optic or oculomotor nerves and defects of other cranial nerves (I, IV-VI). The primary treatment of frontobasilar injuries usually requires a team consisting of a neurosurgeon, an anesthesiologist, a head and neck surgeon and/or a maxillofacial surgeon whose clinical decisions rely on independent assessments of clinical data, the case history and circumstances around the injury and medical imaging. This multidisciplinary team will decide on the priority of management, such as which life-threatening injuries are to be treated first.

Clinical examination including medical, ophthalmologic and neurologic examinations is the first diagnostic step, followed by imaging studies. Once the vital functions have been stabilized by the dedicated emergency team, clinical examination by a head and neck surgeon follows. This examination includes inspection of deformities, lacerations, periorbital edema and hematomas followed by palpation to detect tenderness, palpable bony steps, mobility of fractures and assessment of the integrity or depression of the frontal bone (Katzen et al., 2003, Bell et al., 2007, Piccirilli et al., 2012). Unilateral or bilateral periorbital hematoma (“raccoon eyes”) occurs in over two thirds (78%) of patients with anterior skull base fractures (Herbella et al., 2001). Anterior rhinoscopy or nasal endoscopy reveal nasal bleeding or possible CSF leakage, an examination of oral cavity reveals occlusal problems, while oropharyneal inspection reveals bleeding, lacerations and swelling. Ocular injuries, proptosis, enopthalmos, diplopia and limitation of upward or downward gaze need to be examined (Clauser et al., 2004). Alarming signs of ocular injury, like pain and diplopia, cannot be tested if the patient is sedated or unconscious. Visual evoked potential studies are a reliable method for detection of loss of visual accuracy, even for an intubated patient (Roth et al., 2012). Diplopia can be a sign of oculomotor, trochlear or abducens nerve injuries in association with a fracture through the sinus cavernosus region (Probst et al., 2006).

Massive soft-tissue swelling particularly in the event of panfacial/Le Fort II-III/naso-orbito-ethmoid (NOE)-trauma may limit the clinical examination significantly (Linnau et al., 2003). Crepitations are probably caused by air collection via wounds and fractures. Anosmia can be sign of a cribriform plate fracture, as olfactoria filaments are torn by the fractures (Probst et al., 2006).

Eighty percent of traumatic CSF leaks present as rhinorrhea (Lloyd et al., 2008). Rhinorrhea occurs in 80 % of patients within 48 hours after the trauma (Schlosser and Bolger, 2004). The flow of CSF through the nose can be assessed in a conscious patient by the Valsalva maneuver and by bending the patient's head forward. For an unconsciouss patient bilateral compression of jugular veins may provoke CSF leak (Sherif et al., 2012). A bedside laboratory test for detecting CSF is the 'double-ring sign' for patients with spontaneous leakage of CSF (Sherif et al., 2012). The protein beta-2-transferrin, indicative for CSF, can be identified with as little as 0.5 ml of nasal secretion (Schlosser and Bolger, 2004). Beta-2-transferrin also known as asialotransferrin, is a brain-spesific transferrin with specificity and sensitivity of nearly 98% for CSF leaks and it requires an electrophoretic procedure (Oberascher and Arrer 1986, Oberascher 1988). The most common traditional method, the glucose oxidase test, is based on identification of glucose in the CSF. It is very unspecific and has a high rate of false positive results among diabetic patients and a high rate of false negative results if there is bacterial contamination (Philips et al., 2003, Mantur et al., 2011). Beta-trace protein has been reported as a fast, inexpensive and sensitive CSF test (Arrer et al., 2002) and beta-trace protein together with beta-2-transferrin are recommended for detection of CSF in nasal discharge (Mantur et al., 2011).

The skull base is inaccessible for further clinical examination and imaging is especially important for the diagnostics of skull base lesion.

Imaging diagnostics

Imaging adds important information to the clinical examination and is essential for an adequate understanding of the injury and its extent (Linnau et al., 2003). High-energy trauma to the head requires routinely a cranial-CT study (Novelline, 2004, Provenzale, 2010, Kubal, 2012). CT detects fracture lines and intracranial air (pneumocephalus) but it does not necessarily reveal dural tears and/or CSF leakages (Fraioli et al., 2008, Mantur et al., 2011). In general, CT outlines the bony structures better than MRI, while MRI provides a better resolution of soft tissues (Chong et al., 2004). The CT scanner should be of the multidetector type. A multidetector helical computer tomography (MDCT) scanner with a thin collimation (minimum set value recommended) facilitates rapid acquisition of volumetric raw data. A bone algorithm and isotropic voxels with a thin section reconstruction algorithm allow utilization of multiplanar reformation (MPR) without compromising image resolution and should be standard when images are initially reviewed (Scarfe, 2005, Salvolini at al., 2007, Barest et al., 2009, Provenzale, 2010, Wei et al., 2010). CT data is processed into two-dimensional (2D) and three-dimensional (3D) images (Kubal 2012). Three-dimensional and multiplanar images are currently routine and assess fractures from all angles (Bell and Chen, 2010). MRI is sensitive for the detection of traumatic involvement of brain tissue and dural defects (Chong et al., 2004, Shuknect and Graetz, 2005, Parmar et al., 2009). MRI is recommended if the patient's neurological status is not explained by CT findings alone (Kubal 2012).

The MDCT, direct coronal CT, CT cisternography with iodinated contrast medium, radionuclide cisternography and MRI have been used to localize the osseous and dural defects and any CSF leakage (La Fata et al., 2008). High-resolution MPR images from thin-collimation axial CT data detect CSF leakage quite effectively but not always (La Fata et al., 2008, Parmar et al., 2009). Identification of CSF leakage improves with assessment of the presence of the protein beta-2-transferrin in nasal discharge the patient may have: if beta-2-transferrin is identified, the positive predictive value of CT is enhanced. MRI or CT cisternography are valuable if the skull base contains multiple fractures, (La Fata et al., 2008, Lloyd et al., 2008). MRI cisternography together with photon emission tomography or radionuclide imaging are further used to detect CSF leaks (Mantur et al., 2011). However, these methods are invasive and expensive. Cisternography involves intrathecal application of a radionuclide into the patients's cerebrospinal fluid by lumbar punction. Algin et al. (2010) recommended non-invasive 3D constructive interference in steady state (3D-CISS) as a method of choice for detecting CSF leaks. They compared 3D-CISS and contrast enhanced MRI cisternography (CE-MRC) and found that CE-MRC identified leaks in 100% of the studied cases (Algin et al., 2010). Due to its invasive nature, CE-MRC was however, recommended only in complicated cases where the beta-2-tranferrin test is positive but there is no visible CSF leakage in any of the standard imaging methods used (Algin et al., 2010).

In non-enhanced CT images discontinuity of the carotid canal might be seen, but appropriate evaluation of vascular injury requires contrast media (Borges, 2008, Sun et al., 2011). Computed tomography angiography (CTA) is the preferred imaging technique for evaluation of vascular injury and it can be reliably used to assess intracranial vascular pathology (Wei et al., 2010, Tao et al., 2010). CT angiography should be strongly considered in the diagnostics of patients with skull base fracture to detect vascular injury (thrombosis, dissection or pseudoaneurysm) (Kubal, 2012). A fracture extending through the carotid canal injuring the internal carotid artery may give rise to a pseudoaneurysm, dissection, thrombosis or a CCF (Samii and Tatagiba, 2002). Clinical symptoms of CCF are exophthalmus due to laceration of the internal carotid artery with consequent blood leakage into the orbit. CCF may also cause chemosis and pulsation of the eye. Thrombosis due to carotid wall injury may later cause ocular ischemia or delayed ischemic brain damage. Catheter angiography or MRI may also be useful for assessment of vascular injury (Borges and Casselman, 2007, Borges 2009, Ong and Chong, 2009). The advantage of catheter angiography is that it enables concomitant treatment of endovascular injury (Kubal, 2012).

The novel, useful intraoperative tool in skull base surgery is image-guided-surgery (IGS) or CAS (Mehta et al., 2006, Metzger et al., 2013). CAS is used before the operation for 3D planning, during the operation for navigation and after the operation with cone beam CT (CBCT). Previously, it was used in endoscopic surgery but recently also for open approaches (To et al., 2002). Instruments that are easy to operate and preoperative planning are very useful in traumatology, as in other disciplines (Metzger et al., 2013).

From a technical point of view, the image plane in CT studies should be perpendicular to the examined bone plane to maximize fracture detection. Thus, in the medial skull base at the clivus level, the coronal view is not useful since the clivus lies parallel to the coronal plane. The frontal sinus is best evaluated from axial and sagittal views. The skull base is best viewed from the coronal and sagittal plane, rather than the axial plane, which lies parallel to the direction of skull base (Barest et al., 2009). Axial images are the most useful ones for evaluating the middle cranial base (Avery et al., 2011).

Classifications and algorithms as a tool in diagnostics of anterior skull base trauma

There are different classifications of anterior skull base fractures. They are based on the clinical pattern and CT findings of fractures and on algorithms mainly for the management of these fractures (Escher 1969a, 1969b, Fain et al., 1975, Raveh et al., 1992, Stoll 1993, Asano et al., 1995, Burstein et al., 1997, Sakas et al., 1998, Buitrago-Tellez et al., 2002, Smith et al., 2002, Madhusudan et al., 2004, Meco et al., 2004, Rocchi et al., 2005, Chen et al., 2006, Yilmazlar et al., 2006, Bell et al., 2007, Scholsem et al., 2008, Manson et al., 2009, Echo et al., 2010, Sherif et al., 2012). An ideal craniofacial classification system should be systematic, it should include fracture patterns and presence of relevant information and it should provide information on the severity of the combined with suggestions on how to manage these fractures (Buitrago-Tellez et al., 2002, Sargent 2006).

The classifications, algorithms and management of anterior skull base fractures are presented in Tables 1 and 2.

Table 1. Classifications and management of anterior skull base fractures; literature review

Reference	Types of fractures and principle of classification	Aim of algorithm if described
Escher 1969	Frontobasilar Types I-IV, according to site, extent and direction of force (more detailed description in the text).	
Raveh et al., 1992	Frontobasilar Types I and II, + central and lateral subgroups based by injury pattern and applied force vector (more detailed description in the text).	
Stoll 1993	Frontobasilar Types I-IV, based on anatomy and pathological peroperative findings (dural tears)(more detailed description in the text).	
Asano et al., 1995	Frontobasilar Type I-III according to CT findings. Type I penetrating fractures of orbita and ethmoidal sinus, Type II linear single or multiple fractures and Type III multiple comminuted fractures of anterior skull base. Dural tears always present in Type III fractures.	
Burstein et al., 1996	Frontobasilar types, central, lateral and bilateral, based by clinical pattern on CT images. This classification was used in the planning of elective orbital and cranial access osteotomies. The aim of using elective osteotomies was to gain best possible access and visualization to the injured site, specifically the dura. Osteotomies were used to access the anterior skull base, orbital apices and to gain bony template to recompose fragments of fractures on the side table.	
Sakas et al., 1998	Frontobasilar Types I-IV, took into account location and size, duration of CSF, infection and neurological status (more detailed description is in the text).	To determine whether location and size are related with meningitis.
Buitrago-Tellez et al., 2002	Based on AO/ASIF (Arbeitsgemeinschaft für Osteosynthesefragen/Association for the Study of Internal Fixation) scheme. Types A, B and C, within each 3 subgroups (A1, A2, A3), which further had subgroups (A1.1, A1.2, A1.3) Altogether 27 subgroups. The severity increased from lowest possible (A1.1) to highest possible (C3.3). A was for non- displaced fractures, B for displaced fractures, C for complex fractures. Isolated unit included fractures A1, B1 and C1, combined fractures without skull base injury included fractures A2, B2 and C2. Combined fractures with skull base injury included fractures A3, B3 and C3. Classification was done for midfacial and craniofacial fractures, not solely for frontobasilar fractures.	For fracture type definition (requires knowledge of AO-classification).
Madhudusan et al., 2004	Frontal, basal and combined types→further 9 subtypes taking into account the anatomy, penetrating or blunt injury and association with midfacial fractures. Pure fracture was frontobasilar fracture and impure included associated midfacial fracture.	Aim of the classification was to define anatomical sites, etiology (blunt or penetrating) and association with midfacial injuries in order to assist planning the surgical approach.
Manson et al., 2009	Three fracture patterns; Type I fracture included isolated linear skull base fracture, Type II included vertical linear frontal bone fracture together with linear skull base fracture and Type III was comminuted frontolateral and orbital roof fracture including skull base. The severity of fracture patterns was dependent on direction of transmitted forces. Impure fractures meant combined fractures, which potentially coud affect skull base like NOE and/or Le Fort II and/or Le Fort III. Conclusion of the study was that Type III and impure Type II are associated with CSF fistulas and therefore the treatment must be aggressive.	To aid surgeon to choose suitable management of frontobasilar fractures.

Table 2. Algorithms for the managemt of anterior skull base fractures: literature review. Treatment algorithms are mainly for the detection and treatment of CSF leaks and for the reconstruction of frontal sinus fractures.

Authors	Types of fractures and principle of classification	Aim of algorithm if described
Smith et al., 2002	Algorithm for the management of frontal sinus fracture. Management included open reduction and internal fixation (ORIF), post op antibiotics 4 weeks. Post op CT to follow frontal sinus ventilation. Nasoendoscopic surgery in the event of persistent NFOT obstruction.	To create treatment algorithm for frontal sinus fractures without obliteration.
Meco et al., 2004	Patterns I-IV to detect CSF fistula, based on symptoms and etiology. Pattern I for assessment of CSF leak and dural tear after head trauma. Patterns II for postoperative CSF leak. Patterns III was for spontaneous CSF rhinorrhea and Pattern IV for recurrent pneumococcal meningitis due to dural tear. Anterior skull base was divided into four compartments; I included frontal sinus II a cribriform plate, II b ethmoidal fovea and III sphenoidal sinus.	To tell whether or not there was a dural tear or CSF leak.
Rocci et al., 2005	Criteria for operative treatment included same parameters as Sakas et al. (1998) had reported earlier. Those were bone displacement >1cm, fracture proximity to midline, fracture of cribriform plate, encephalocele and unsuccessful conservative treatment.	To create treatment algorithm for the management of posttraumatic CSF fistula.
Chen et al., 2006	Teatment algorithm for frontal sinus fractures. Management of frontal sinus fractures was divided into four categories; conservative treatment, ORIF of anterior table and preservation of sinus mucosa, obliteration and cranialization.	To facilitate decisionmaking. Highlighted presence of persistent CSF leak and NFOT injury.
Yilmazlar et al., 2006	Treatment algorithm for traumatic CSF leak following skull base fracture. Primary Glasgow Coma Scale (GCS) score and presence of intracranial lesions were the determining facts. GCS 8 or lower without intracranial injuries meant conservative treatment with CSF drainage but with intracranial injuries it meant operative treatment. GCS>8, no intracranial injuries lead to bed rest 3-7 days, GCS>8 with intracranial injuries lead to surgical treatment.	To choose between conservative and and operative treatment options.
Bell 2007	Algorithm for the management of frontal sinus fractures based on displaced fracture of anterior or posterior table, injury to NFOT and on neurological status. Treatment modalities were three; ORIF of anterior table fracture without manipulation of sinus mucosa, removal of mucosa and obstruction of NFOT with abdominal fat and ORIF of anterior table fracture. The third option included cranialization, removal of sinus mucosa and obliteration of NFOT with pericranial flap.	To choose between conservative and operative treatment options and to have predictable outcome following use of a protocol.
Scholsem et al., 2008	Treatment algorithm for the management of traumatic CSF leak. Indications for operative treatment included rhinorrhea, subdural pneumocephalus and meningitis. Surgical method was either intracranial or extracranial and it was based on fracture dislocation and comminution. For patients with extensive skull base defects the intracranial bifrontal craniotomy was the method of choice.	To choose between conservative and operative treatment options, and between different surgical methods.

Authors	Types of fractures and principle of classification	Aim of algorithm if described
Echo et al., 2010	Treatment algorithm for frontal sinus fractures. Options were conservative treatment, endoscopy, obliteration, cranialization and reconstruction. Criteria for cranialization were displaced posterior wall fractures, CSF leak lasting at least one week and always if the craniotomy was indicated. Criteria for obliteration included NFOT obstruction and frontal sinus floor and ethmoid fracture. Reconstruction criteria included displaced anterior frontal sinus fracture with ORIF.	The aim of the treatment algorithm was to reduce possibly associated morbidity by providing treatment options in exactly categorized fractures.
Sherif et al., 2012	Algorithm for the management of CSF leaks in anterior skull fractures. The classification they used was that of Sakas (Sakas et al., 1998). Initial GCS (GCS ≤13 was an indication for ICU treatment), presence of CSF leak and CT findings were mainstays of the algorithm. Patients were divided into 3 subgroups. In group 1 patients had acute indications for surgery, in subgroup 2 patients had no acute surgical indications and they were primarily managed conservatively, in subgroup 3 patients had mild TBI (GCS over 13) and they were dealt conservatively.	The algorithm perceived acute surgical indications and initial conservative treatment strategies in closure of CSF leaks associated with anterior skul base fractures.

Of the nine different classifications in Table 1, eight were purely frontobasilar fracture classifications (Escher 1969a, 1969b, Raveh et al., 1992, Stoll 1993, Asano et al., 1995, Burstein et al., 1997, Sakas et al., 1998, Madhusudan et al., 2004, Manson et al., 2009). The classification by Builtrago-Tellez et al. (2002) included craniofacial and midfacial fractures. Four of these nine classifications are described more thoroughly below because Escher's classification is a basis for the classification by Stoll (Escher 1969a, Stoll, 1993, Stoll, 1999) and the classification by Raveh is influenced by the subcranial craniotomy approach (Raveh and Vuillem 1988a, 1988b). The classification by Sakas et al. (1998) has been used as a basis in two different algorithms for the management of posttraumatic CSF fistula (Rocchi et al., 2005, Sherif et al., 2012).

In the classification by Franz Escher (1969) frontobasilar fractures were classified into four categories, Types I to IV, according to the fracture site, the extent of the fracture and the direction of the trauma force (Escher 1969a). This classification further divides fractures into high, middle, low and lateral ones. In the Type I, the direction of the force is direct to the frontal bone affecting the frontal sinus with possible dural tear and brain injury, which is considered to be a high fracture. This type is seen as extensive injuries. Type II fractures include fracture of the anterior and/or posterior ethmoid sinus and the cribriform plate with or without CSF leakage and the fracture runs along the ethmoid sinus and cribriform plate. This fracture is considered to be a middle fracture and a localized fracture. Type III fracture includes sphenoid sinus injuries with or without CSF leakage and the fracture line runs low. Midfacial avulsion from the skull base is possible. In the fronto-orbital or latero-orbital Type IV fracture, the force acts on the orbito-temporal region which, fractures the frontal sinus and orbital roofs of the frontobasal area (Escher 1969a, Hardt and Kuttenberger, 2010).

Stoll (1993) used a classification, which is modified from Escher's classification; it takes into account the anatomy and intraoperative findings, such as CSF leakage (Escher 1969a, 1969b, Stoll, 1993, Stoll, 1999, Hardt and Kuttenberger, 2010). Stoll felt that Escher's classification lacked some detailed facts of the trauma, specifically related to the frontal base. Frontobasilar fractures (FB) were classified into four categories, Types I to IV, according to the anatomy and pathological intraoperative findings of the trauma (Stoll, 1993, Stoll, 1999). Type I (FB I) included frontal sinus fractures including either anterior or posterior or both tables, with or without CSF leakage. Type II fracture (FB II) included fracture of the anterior and/or posterior ethmoid sinus and cribriform plate with or without CSF leakage. Type III fractures (FB III) included sphenoid sinus injuries with or without CSF leakage and type IV (FB IV) included fractures of the orbital roof with or without CSF leakage.

The classification by Raveh is influenced by the subcranial craniotomy approach he presented 1978 for the reconstruction of anterior cranial base fractures (Raveh and Vuillem 1988a, 1988b). Raveh et al. divided frontobasilar fractures into two types (Raveh et al., 1992, Bell and Chen, 2010). In Type 1, the impact fractures the outer facial frame and buttresses absorb and soften the impact preserving the posterior structures and consequently Type I does not consist of skull base fracture. Type I fracture occasionally includes an optic nerve injury if the fracture runs via medial orbital wall as far as the orbital apex. This rare fracture type is called Type 1a. In Type 2 fractures, the high-energy impact is so excessive, that both the outer frame and inner structures are injured and optic nerve compression occurs often. Both types can further be divided into central and lateral types according to the pattern of the fracture and by the force vector.

Two different algorithms for the management of post-traumatic CSF fistula (Rocchi et al., 2005, Sherif et al., 2012) are based on the classification by Sakas et al. (1998). In the original classification, Sakas et al. (1998) took into account the location and size of the fracture and further the duration of the CSF leakage, infection and neurological status, when deciding whether a patient should be treated conservatively or operatively. The initial aim of the study was to determine whether location and size are associated with meningitis following trauma (Sakas et al., 1998). Type I included the cribriform plate without involvement of the frontal or ethmoid sinus, Type II was frontoethmoidal fracture, Type III was lateral frontal fracture and Type IV complex fracture i.e., a combination of Types I-III. Predictors of meningitis were Type I and Type II, fracture size over 1cm and rhinorrhea over 8 days and therefore the authors recommended that these conditions should be treated surgically (Sakas et al., 1998).

2.2.3 Treatment of frontobasilar fractures

The goals of treatment are to sustain frontal sinus function, restore facial esthetics end prevent long-term complications. Among the complications of frontobasilar fractures are CSF leakage, meningitis, brain abscess, mucocele, mucopyocele, epidural abscess, chronic pain in the frontal area, chronic frontal sinusitis, diplopia, seizures and esthetic asymmetry of the forehead. The prevention of these complications is essential and directs the treatment decision to surgery or no surgery. The options are conservative treatment with close follow-ups and operative treatment with ORIF or endoscopic surgery. Decision making is dependent on the dislocation of any fractures, associated intracranial and facial injuries, injuries to nasofrontal outflow track (NFOT) in frontal sinus and on the patient's compliance with regular check-ups (Koento 2012). In general, conservative treatment is chosen when there is no CSF leakage, no pneumocranium and fractures are undisplaced (Raveh et al., 1988, Fishman et al., 2009). Conservative management includes often bedrest, close follow-up, antibiotics and if required, lumbar drainage (Fishman et al., 2009). Antibiotics are required because there is a risk of meningitis and other intracranial infections associated with skull base injuries, especially in patients with CSF leakage. However, a recent (2011) Cochrane review does not support prophylactic use of antibiotics in patients with basilar skull fractures until large randomized controlled trials are available (Ratilal et al., 2011). Arguments against the use of antibiotics include the fact that antibiotics penetrate poorly uninflamed meninges and that they do not eradicate pathogens (e.g., *Pneumococci*) from the upper respiratory tract. Antibiotics also increase the risk of microbes resistant to antibiotics (British Society for Antimicrobial Chemotherapy 1994, Greig, 2002). CSF leaks resolve spontaneously in approximately 25% of patients with frontobasilar fractures, if there is no major bone displacement involved (Yilmazlar et al., 2006). Conservatively treated patients may benefit from lumbar drains if the CSF leaks persist for more than 48 hours (Sherif et al., 2012).

Probst et al. (2006) divided the indications for surgery into three categories. In the first category were the patients with vital indications requiring immediate surgery (increased intracranial pressure due to intracranial bleeding, bleeding from an open skull fracture or the nose, not treatable conservatively). The second category included patients with absolute indications for urgent operative treatment e.g., open brain trauma, dural tears, penetrating injuries, infection like meningitis and brain abscess. Patients in the third category included those with relative indications for surgery within two weeks; displaced fractures, if there was acute or chronic sinusitis at time of injury and if there was post-traumatic sinusitis or traumatic supraorbital injury (Probst et al., 2006).

The surgical methods can be divided into intracranial and extracranial (Fishman et al., 2009). Various surgical methods have been recommended for the repair of the defects of the anterior skull base (Scholsem et al., 2008, Komatsu et al., 2011, Moe et al., 2011, Husain et al., 2013). Computerized planning of surgery, image guidance and minimally invasive techniques throughout have been introduced into craniomaxillofacial traumatology, and frontal skull base fractures are being treated by extracranial endoscopic techniques more and more often (Kirtane et al., 2005, Hadad et al., 2006, Komatsu et al., 2011, Roehm et al., 2011, Husain et al., 2013). Comminuted fractures of the cranial base, intracranial lesions and lateral extension of frontal sinus fractures are, however, still contraindications for endoscopic repair (Scholsem et al., 2008). Combined intracranial extradural and intradural tehcniques to repair complex anterior skull base fractures with CSF leaks have been used (Scholsem et al., 2008). The neurosurgical approaches for reliable closure of dural defects of the anterior skull base involve microscopic intradural inspection and microsurgical repair and standard procedure for repair of CSF leak has been microsurgical bifrontal intradural approach (Samii and Tatagiba, 2002, Rocchi et al., 2005). According to Bell and Chen (2010) aims and principles of reconstruction consist of the coronal surgical approach, treatment of intracranial injuries, repair of dural tears, separation of the neurocranium from the nasal cavity, optic nerve decompression, treatment of frontal sinus fractures with cranialization, orbital roof repair, repair of orbital volume and ORIF of craniofacial fractures (Bell and Chen, 2010).

The first closure of a CSF fistula was performed by Dandy in 1926. The approach was through a frontal craniotomy (Dandy 1926). This method has been used for decades ever since. The epidural transethmoidal rhinosurgical approach to the central skull base was used by Escher in the 1940's but the disadvantage of this approach is that there was access only to the cribriform plate and sphenoethmoidal region (Escher, 1969a). Malecki (1959) described a combined rhino-neurosurgical approach for the repair of posterior frontal sinus and ethmoid and sphenoid roof fractures. He described the method as a transantral, frontal craniototomy and intradural control of the skull base. The traditional transfrontal intracranial approach includes disadventages like morbidity, frontal lobe manipulation and consequent neurological deficiencies, cerebral edema and memory problems. The disadvantages related to the transcranial neurosurgical approach were well avoided by the subcranial approach (Raveh and Vuillem 1988a, Raveh et al., 1988, Raveh et al., 1995, 1998, Fliss et al., 2007). To reduce the morbidity associated with the traditional technique, Joram Raveh presented subcranial approach in 1978 for the treatment of combined frontobasal-midface fractures (Raveh et al., 1988). This technique used the transethmoidal approach, which provides broad subcranial access to all anterior fossa planes. The same technique was used for correction of craniofacial deformities and for the removal of skull-base tumors (Raveh and Vuillem 1988b, Raveh et al., 1995). The subcranial craniotomy technique is a modified transethmoidal approach, which exposes the anterior skull base from the roof of the ethmoid sinus to the clivus posteriorly and to the orbital roofs laterally. Optic nerve decompression, repair of medial canthal tendon and ORIF of midfacial fractures are all possible in one session (Raveh et al., 1988). The primary goal of the subcranial approach was to make a one-stage repair of all fractures within 24 to 48 hours after the trauma. Only patients with severe intracranial injuries had their surgery postponed. In early reports an eyebrow incision was used, but soon the coronal incision became the incision of choice in this technique (Raveh and Vuillemin, 1988, Raveh et al., 1992, Kinnunen and Aitasalo, 2006).

Fracture of the posterior wall of the frontal sinus indicates a high possibility of dural tear and associated intracranial injury. Watertight and airtight closure of the fistula from the intracranial space to the sinonasal cavity is essential. Closure is important in both, when comminuted anterior cranial base fractures are treated and when minimally displaced fractures are treated endoscopically. A free fascia graft is the standard. It is often derived from the fascia lata or the temporalis fascia and applied in a multilayer style. Fibrin glue is frequently used to facilitate initial tissue attachment (Shohet et al., 2008). For prevention of graft migration, specifically designed clips can be used (Snyderman et al., 2007). Large bony defects warrant bone grafts (Shohet et al., 2008). Posterior wall fractures with associated dural tears and brain injuries are often treated by removal of the posterior bone wall together with mucosal tissue and obstruction of NFOT in the posteromedial floor of the frontal sinus (cranialization). After removal of the posterior table and mucosa, the cerebral tissue is allowed to rest against the repaired anterior table and sinus floor. A pericranial flap is regularly used for protection between the anterior table, sinonasal tract and brain tissue (Donath and Sindwani 2006). Another alternative is the subcranial approach with galeofrontal or pericranial flap reconstruction in associated naso-orbito-ethmoidal fracture repair requiring removal of ethmoidal cells (Rontal 2008). In subcranial craniotomy approach the polyethylene tubes (Portex®, Sims Portex Ltd., Kent, UK) are placed from the frontal sinus to the nasal cavity for aeration and re-growth of sinus cavity mucosa; in this procedure cranialization is avoided (Raveh and Vuillemin 1988).

In addition to cranialization, frontal sinus obliteration is suggested by some authors when the posterior wall of the frontal sinus is fractured and the NFOT is injured (Piccirilli et al., 2012, de Melo et al., 2013). However, some authors do not recommend obliteration, if there is posterior table involvement (Bell et al., 2007). The NFOT (or synonymous frontal sinus outflow track, FSOT) injuries may be clinically the most important injuries in frontal sinus involvement (Koento 2012). The NFOT injuries occur in one third of the frontal sinus fractures (Stanley et al., 1987, Heller et al., 1989). Injuries to NFOT and displaced fractures of posterior wall of the frontal sinus are treated surgically, regardless of technique. NFOT injuries require complete removal of the sinus mucosa to prevent mucocele. This can be achieved by obstruction (obliteration) of NFOT after removal of frontal sinus mucosa in cases where the floor of frontal sinus is not comminuted (Gonty et al., 1999, Fraioli et al., 2008). Obliteration can be done by filling the sinus with adipose tissue, a pericranial flap, bone, bone cement, bioactive glass or alloplastic material (Weber et al., 1999, Peltola et al., 2008, Rontal 2008). If the posterior wall is severely fractured the cranialization is frequently needed (Gonty et al., 1999, Bell et al., 2007, Fraioli et al., 2008).

For patients with extensive skull base defects and multiple fractures of the ethmoid and posterior frontal table, associated with intracranial hematomas or involvement of cranial nerves, the intracranial bifrontal craniotomy is still the method of choice with reasonably low complication rates (Scholsem et al., 2007). The monitoring of intracranial pressure (ICP) dictates the clinical decision making and in some clinics a ventriculostomy is placed by a neurosurgeon routinely for every patient who undergoes repair of frontobasilar fractures (Bell and Chen, 2010). Decompressive craniectomy, multimodal monitoring, cerebral microdialysis, monitoring of intraparencymal brain oxygenation and cerebral blood flow monitors are used to control the cerebral odema and elevated ICP (Bell and Chen, 2010). Lumbar drains are used regularly in some centers postoperatively when the ICP is normal and the patient does not have an external ventricular drain (Sherif et al., 2012).

2.2.4 Outcome after anterior skull base injuries

Outcome without traumatic brain injury; extracranial aspects

The outcome depends on the severity of injury. In severe injuries it is likely that the patient has various short-term and long-term sequelae (Bell et al., 2007). An unsatisfactory outcome is related to dural lacerations, infections and dammage to neurovascular structures (Manson et al., 2009). NOE-fractures and Le Fort II-III fractures associated frontobasal injuries comprise over half of the frontobasilar fractures but account for 76% of the complications (Manson et al., 2009).

Pseudohypertelorism or telecanthus is defined as an increased intercanthal distance and is a consequence of separation of the medial canthal tendons in naso-orbito-ethmoidal trauma. The medial canthal tendons have their insertions in the lacrimal crest of the medial part of the orbit and comminuted fractures in that particular area warrant surgical treatment (Zide and McCarthy, 1983, Hopper et al., 2006, Patel et al., 2012). Untreated traumatic telecanthus results in marked impairment in terms of cosmetic and functional outcome (Baumann and Ewers, 2001, Elbarbary and Ali, 2014). Functionally, the medial canthal tendon covers the lacrimal sac and movement of the tendon and muscles enhances the flow of tears through the nasolacrimal duct. Esthetically, the medial canthal tendon forms a sharp angle in the medial palpebral fissure and an ideal distance between the medial canthi is one third of the distance between the lateral canthi and half of the interpupillary distance. Secondary correction of a primarily delayed or suboptimal correction of telecanthus is extremely difficult. Medial canthopexy with transnasal wiring has been the technique of choice also of secondary repairs (Elbarbary and Ali, 2014, Kim et al., 2014).

In anterior cranial base fractures, the risk of meningitis is associated with the size of the fracture (the risk increases when the size is over 1 cm), the site of the fracture (the closer the fracture is midline, the higher is the infection rate due to close relation of nasal cavity to cribriform plate) and rhinorrhea persisting over 8 days (Sakas et al., 1998). The frequency of serious infectious complications following frontal sinus trauma and consequent surgery is 0% to 50% with an estimated average of 9% (Chuang and Dodson, 2004).

Persistent diplopia resulting from injury to the trochlear nerve during a surgical procedure in the region of the medial and superior orbital wall is a well known complication following anterior skull base surgery (Grabe et al., 2013). Three percent of patients with facial fracture will have traumatic blindness caused by injury to the orbital apex and the optic nerve (Stanley et al., 1998). Optic nerve compression is not uncommon in anterior skull base trauma (Chen et al., 2004). Indirect causes for traumatic blindness are retrobulbar hemorrhage and traumatic optical neuropathy (TON) (Roth et al., 2012). The etiology of TON is multifactorial; injury to ocular globe, edema and bleeding around the optic nerve and reduced blood flow causing hypoperfusion and ischemia with injury of neural cells involved (Warner and Eggensberger, 2010).

Follow-up is essential for prevention of long-term complications. The duration of follow-up is debatable and even life-long follow-up has been recommended (Koudstaal et al., 2004, Swinson et al., 2004, Mourouzis et al., 2008). Mucoceles or mucopyoceles from the frontal sinus mucosa may emerge still 34-50 years after the trauma (Koudstaal et al., 2004, Mourouzis et al., 2008). Worrisome clinical signs include frontal headache, swelling in the upper eyelid or forehead, diplopia, ptosis, nasal secretions and obstruction. High-resolution, thin-slice CT images are used during follow-ups.

Outcome following traumatic brain injury and anterior skull base fracture; intracranial aspects

The TBI among anterior skull base injuries is approximately 3-11% (Hardt and Kuttenberger, 2010, Bell et al., 2010). In severe skull base injuries TBI is often strongly related with a poor outcome. The incidence of TBI in Finland was 101 per 100 000 over the period from 1991 to 2005 and associated mortality was 18 per 100 000 (Koskinen and Alaranta, 2008). The annual incidence of TBI in the United States varies between 180-250 and 506 per 100 000 (Bruns and Hauser 2003, Selassie et al., 2008). In Finland, the annual costs related to TBI in tertiary care are 50 million euros and the annual productivity loss in terms of retirement due to TBI varies nationwide from 470 to 760 million euros (Joelson et al., 2011). Half of the TBI occur to persons aged 15 to 34 years (Jennett 1996). These young people face many years of mental and physical disability as the brain injury causes cognitive and behavioral problems and funtional impairment (Jennett et al., 1981). The prognosis of TBI is based largely on the definition of the severity of brain damage. Several factors like GCS on admission, duration of unconsciousness, duration of loss of memory, neurological deficiences following trauma and radiological findings of brain injury in CT or MRI have been used to assess the severity of TBI. Clinical factors, which affect the prognosis and outcome are the patient's age, GCS, associated injuries, hypotension, hypoxia and intracranial hematomas (Luerssen et al., 1988).

There are only a limited number of accurate prognostic factors for patients with severe TBI. There have been attempts to predict the prognosis after TBI, not only by clinical predictions but also with an aid of statistical models. One such attempt was the computer based prognostic prediction of outcome using a model based on a large cohort of 10 008 patients with TBI (MRC CRASH Trial Collaborators 2008). The basic variables included the patient's age, GCS, pupil reactivity and major extracranial trauma. Additional variables were petechial hemorrhages, third ventricle or basal cisterns obliteration, subarachnoidal haemorrhage (SAH), midline shift and non-evacuated hematoma seen on CT scans. The predictors of outcome were different between high-income and middle to low-income countries. The study showed that older age, low GCS, absence of pupil reaction, major extracranial injury and significant CT findings (subarachnoidal hemorrhage, petechia, third ventricle or basal cistern obliteration, mid-line shift and non-evacuated hematoma) were predictive of a poor outcome (MRC CRACH Trial Collaborators 2008). Being involved in a motorcycle accident as driver, passenger or victim, GCS < 8 at 24-48 hours after the injury and diffuse axonal injury (DAI) are unfavorable predictive variables of outcome (Lee et al., 2012). Male gender and living in a region of socioeconomic deprivation are risk factors for TBI (Bruns and Hauser 2003).

Glasgow Outcome Scale (GOS) is a universal method for reporting disability after severe head injury. It has several variants. The original version divided outcome into five categoeries: death, vegetative state, severe disability, moderate disability and good recovery (Jennett and Bond, 1975). There are several other classifications for conscious patients, i.e., classifications that exlude patients in a vegetative state (Heiskanen and Sipponen 1970, Overgaard et al., 1973, Jennett and Bond 1975). One variant of the GOS divided survivors into two categoeries: severely disabled (including vegetative and severely disabled patients) and independent (patients with moderate disability and good recovery) at 6 months and 12 months (Jennett et al., 1981). In a study of severely brain injured children, the mean 2-year GOS was related to GCS at presentation: the lower the GCS, the worse the outcome two years after the trauma (Jagannathan et al., 2008). A significant number of patients even with mild TBI develop neuropsychiatric symptoms by one year after injury (Deb et al., 1998). The most common neuropsychological problems are irritability, impatience and sleeping disorders followed by fatigue and poor concentration (Deb et al., 1998). The prevalence of depression after TBI is 16% to 61 % (Kim et al., 2007).

The overall prognosis after TBI has increased over the last 20-30 years and the mortality rate has decreased from 80% to 20% (Marshall et al., 1998, Gentleman 1999). A substancial proportion of patients (43%) admitted for TBI patients still have long-term disabilities (Selassie et al., 2008).

2.2.5 Pediatric skull base and frontobasilar fractures: epidemiology, treatment and outcome

Maxillofacial fractures in children are uncommon and children under the age of 10 comprise 3% to 14% of all maxillofacial fracture patients (Cheema and Amin, 2006, Kadkhodaie 2006). The overall prevalence of panfacial and upper facial fractures in childhood is low (Ferreira et al., 2005). Skull vault fractures are the most common craniofacial injury in early childhood (McGraw et al., 1990, Lallier et al., 1999, Chan et al., 2004, Eggenesperger et al., 2008). Midfacial and mandibular fractures are more common in older children (Posnick et al., 1993, Chan et al., 2004). Young children have a prominent frontal region, which predisposes them to upper facial injuries, while older children have frontal projection that is more of an adult’s and therefore older children and adolescents are more prone to mandibular injuries (Imahara et al., 2008). The frequencies of pediatric skull base fractures vary in literature and the numbers are not directly comparable. In a US study of 277,008 pediatric trauma patients 27% of 12,739 facial fracture patients had a skull base fracture and 32% had brain injury (Imahara et al., 2008). In a Finnish study of 378 children, 3.2% of the facial fractures were fractures of the upper midface and of those about one third were frontobasilar fractures (Thorén et al., 2009). In a Swiss study of 291 children with craniomaxillofacial fractures the most common pediatric craniofacial trauma was fracture to the skull vault (54%) followed by fracture to the upper and middle face with percentage of 37% (Eggenesperger Wymann et al., 2008). Orbital roof fractures were the most common facial fractures in a study by Chapman et al. (2009), particularly in children under nine years of age. The prevalence of pediatric skull base fractures in children with head injuries varies from 5% to 46% (Mealey 1968, McGuirt et al., 1992, Johnson et al., 2005, Jagannathan et al., 2008).

The facial bones of children are more elastic and have thick adipose tissue surrounding them, which makes the facial bones more resistant to fractures. Also, unerupted teeth stabilize the mandible and maxilla (Vyas et al., 2008). The small size and poor pneumatization of the paranasal sinuses affect the occurrence of frontobasilar fractures in children (Thorén et al., 2011) and fractures of the forehead in children are preferentially skull fractures, not frontal sinus fractures since the paranasal sinuses lack aeriation.

RTA is the main cause of facial trauma during childhood, but toddlers and younger children are subject to other causes, mainly falls and hits by a motor vehicle. Older children are prone to bicycle accidents and later in adolescence violence becames a more frequent cause of facial trauma (Imahara et al., 2008).

Fractures of the skull base are potentially fatal and head injury is one of the leading causes of death of children. About one third of all pediatric patients with a facial fracture have some associated brain injury compared to those with no fracture (Imahara et al., 2008). In a study by Schaller et al. (2012) brain injury was present in 59% of children with a frontal skull base fracture. The most common (33%) associated injury is cerebal concussion (Eggensperger Wymann et al., 2008). Fortunately, functional outcome is good among most (73% - 82%) children with brain injuries (Jagannathan et al., 2007, Thomale et al., 2010). In a series of 53 children with severe traumatic brain injury, the overall one-year outcome analysis showed that the outcome was favorable and that the children experienced a good recovery with only moderate disability among 86% of the patients (Thomale et al., 2010). It may take several months for maximal recovery following TBI of pediatric patients (Jagannathan et al., 2008). After 2 to 5 years 92% of the head injury survivors had returned to school while 8% of patients remained severely disabled (Thomale et al., 210). The death rate of children with skull base trauma varies between 1.6% and 14% (Liu-Shindo et al., 1989, Ort et al., 2004). Children under the age 14 years have lower mortality rates than older patients (Luerssen et al., 1988).

13% - 25 % of all pediatric patients admitted for treatment of facial fractures need operative treatment (Eggensperger Wymann et al., 2008, Imahara et al., 2008). The relative need of operative treatment seems to increase with age and the age group of 14 - 18 years need most surgery. Conservative treatment is often sufficient among the younger children as children of this age have an enhanced healing and remodeling capacity (Imahara et al., 2008). Operative intervention may also impair growth of the immature skeleton. Growth interference may be minimized with the use of resorbable plates and screws for facial fracture repair and craniomaxillofacial surgery. Consequently, such materials have become common and no major long-term complications have been reported, nor is there a need for secondary operatios to remove the plates (Eppley 2005, Goodrich et al., 2012). Surgery is generally warranted if there is bone displacement, suspicion of a dural tear and active CSF leakage (Fishman et al., 2009). Then the general principles of trauma treatment are followed with reduction and fixation (Fishman et al., 2009). Head trauma and CSF leakage may be treated through a combined subcranial and subfrontal approach by simultaneous repair of any maxillofacial injuries (Fishman et al., 2009).

3 AIMS OF THE STUDY

The general objectives of the present study were to characterize the epidemiology of facial injuries with special focus on the diagnostics, management and outcome of frontobasilar fractures.

The specific objectives were:

1. To explore the lifetime prevalence of dental injuries and risk factors for dental injuries in a general population-based longitudinal birth cohort of 5737 subjects. The aim was also to examine the associations between dental injuries and some social and health variables (Study I).

2. To describe the different types of mandibular fractures in patients from three different countries (Study II).

3. To study the management and outcome of pediatric skull base and frontobasilar fractures in a single institution, academic tertiary referral centre (Studies III and IV).

4. To study the precision and diagnostic content of a systematic image-reviewing algorithm of CT images for planning of operative treatment of frontobasilar fractures (Study V).

5. To describe the management and outcome of adult frontobasilar fracture patients operated on with the subcranial craniotomy approach (Study VI).

4 MATERIALS AND METHODS

4.1 Design of studies I-VI

This series of studies consists of an epidemiological cohort study (I) and five retrospective (II-VI) clinical studies. The individual study designs are presented in Table 3.

Table.3. Study design and number of patient

Study	Study design	N
I	Cohort study of an unselected, general population-based longitudinal birth cohort in 1997	5737
II	Retrospective multi-center study based on medical records in Canada, Finland and Kuwait in the 1990's	1092
III	Retrospective study based on the medical records of all pediatric patients diagnosed with a fracture of the skull base in 1996 - 2009 at the Turku University Hospital	63
IV	Retrospective study based on the medical records of all pediatric patients diagnosed with a fracture of the frontal skull base in 1995 - 2010 at the Turku University Hospital	20
V	Cross-sectional cohort analysis of the radiological data of all patients diagnosed with fracture of the anterior skull base at the Oulu University Hospital in 2007 – 2011 and at the Turku University Hospital in 2010 -2011	27
VI	Retrospective study of clinical data of all patients diagnosed with frontobasilar fractures during the period from 1996 to 2011 at the Turku University Hospital	48

4.2 Epidemiology of dental injuries (I)

4.2.1 Data collection

The material consisted of an unselected, general population-based longitudinal birth cohort of 12 058 live births covering 96.3% of the newborns in Northern Finland in 1966. The design of the Northern Finland 1966 Birth Cohort study has been decribed in detail (Rantakallio and von Wendt 1986, Rantakallio 1986). Of the cohort 11 637 persons were alive in 1997 and 8463 were living in the northernmost provinces of Finland and in the Helsinki area. These 8463 subjects received a postal questionnaire with questions on their physical and mental health and occupation. As a part of this 31-year follow-up study, an invitation to a clinical examination was offered to all cohort members as part of the questionnaire. The clinical examination included measures of weight and height. Altogether 5737 cohort members participated in the field study, completed the questionnaire and returned a consent form. They served as subjects of the study. The health status, including dental traumas, was assessed by self-reporting illnesses and the subject's own view of their health status. Fifty-two percent of participants were women and 48% were men. There were 2726 non-attenders. Of them 51% were women and 49% were men.

4.2.2 Methods

The computer-based questionnaire (Appendix 2) included the following questions regarding previous dental trauma: 1) Have you ever had traumatic dental fractures (broken teeth)? 2) Have you had traumatically loosened or missed teeth (displaced, luxated or exarticulated teet)?

The background factors related to dental fractures, traumatic displacements (luxations) and missing teeth (exarticulations/avulsions) were gender, mental distress, alcohol consumption, body mass index (BMI), malocclusion, previous non-dental injuries, physical activity and socioeconomic status. Mental distress was assessed by the Hopkins Symptom Check List (HSCL) (Appendix 1). The HSCL-25 includes 25 questions on the presence and intensity of anxiety and depression symptoms over the past week. The HSCL is a commonly used method for estimating psychiatric distress. Originally, it was a 90-item questionnaire (Derogatis et al. 1973) but various abbreviated versions have been presented since. The validity and reliability of the HSCL are satisfactory measures of mental symptoms (Glass et al., 1978, Hough et al., 1990), and the HSCL can differentiate between healthy and neurotic subjects (Risckels et al., 1972, Sandager et al., 1998). The HSCL-25 has been used in the Nordic countries for screening and other purposes (Joukamaa et al., 1994, Fink et al., 1995, Munk-Jorgensen et al., 1997). The answers were scored on a scale from 1 (not worried) to 4 (extremely worried). The HSCL-25 score was the sum of items divided by the number of items answered. The HSCL-25 mean score of ≥ 1.55 was considered to indicate distress in this study.

In the postal questionnaire (Appendix 1), the frequency of alcohol consumption and the number of alcohol drinks (wine, beer or spirits) consumed on a single drinking occasion was asked. Based on the reported alcohol consumption, the subjects were classified into three groups: 1) no alcohol use (abstainers), 2) low or average consumers: females who consumed 1-4 units (12 g alcohol/ unit) per occasion or less than 16 units per week or males who consumed 1-6 units per occasion or less than 24 units per week and 3) heavy drinkers: females who consumed 5 units or more per occasion or over 16 units per week or males who consumed 7 units or more per occasion or over 24 units per week.

A body mass index (BMI: kg/m^2) of ≥ 25.0 was considered overweight. Both weight and height were measured and calculated as part of the field study when the participants were aged 31 years.

Malocclusions were divided into retrognathic and prognathic mandible and prognathic maxilla based on the questions asked. The following questions regarding occlusal and skeletal aspects were asked: 1) Is your lower jaw clearly retrognathic compared to upper jaw? 2) Is your lower jaw prognathic compared to upper jaw? 3) Are your upper front teeth (incisors) protruding?

Etiologies for previous non-dental injuries consisted of road traffic accidents, occupational injuries, domestic or sports injuries, assaults and other non-occupational injuries.

The participants' regular physical activity was recorded. Physical activity was regarded as regular if the respondent became breathless and had at least mild sweating. The frequencies of regular exercise were: 1) 0-3 times per month, 2) 1-3 times per week and 3) 4-7 times per week.

The purpose of the classification of the respondent's socioeconomic status was to describe the distribution of the study population into different groups. The factors determining socioeconomic status included the stage of life cycle, occupation and employment status. There were eight categories of socioeconomic status: 1. self-employed (farmers), 2. self-employed (others), 3. upper-level employees with administrative, managerial, professional and related occupations, 4. lower-level employees with administrative and clerical occupations, 5. manual workers, 6. students, 7. Retired, 8. unemployed (people with no occupation and no working experience) and 9. other, whose socioeconomic status was unknown. This socioeconomic status description was generally recognatized by Statistics Finland (www.tilastokeskus.fi). To increase the sample size in the small categories, categories 1 and 2, 4 and 5 as well as 7 and 8 were combined, categories 3 and 6 were studied separately. Thus, there were 5 categories.

4.3 Epidemiology of mandibular fractures (II)

The data were collected consecutively of 1092 mandibular trauma patients from the Toronto General Hospital, Canada, the Oulu University Hospital, Finland and from 22 hospitals in Kuwait. The data on fractures in Canada included the years between 1995 and 2000, in Finland between 1990 and 1999 and in Kuwait between 1991 and 2000. The collected data was based on patient records and radiographs. There were altogether 1552 mandibular fractures in the study population. The diagnosis in Kuwait was based on clinical examination and computed tomography or skull radiographic views, not necessarily on panoramic radiographs. In Kuwait the data was collected prospectively. The data were evaluated and the fractures were diagnosed by specialists in oral and maxillofacial surgery. The files in Kuwait do not necessarily include radiographs, which were the property of the patients.

The fracture location was evaluated by examination of the available radiographs. The locations were divided into condylar, ramus, angle, body and symphyseal regions. In

Kuwait mandibular alveolar fractures were included in the study. The etiologies were divided into five categories: 1) RTA's, 2) falls, 3) violence, 4) sports and 5) other causes. Violence included interpersonal fights and falls included both falls from the heights and falls from standing to the ground.

4.4 Frontobasilar fractures (Studies III-VI)

4.4.1 Skull base and frontobasilar fractures in pediatric patients (Studies III and IV)

The medical records of all patients diagnosed with a fracture of the skull base during the period from January 1996 to May 2009 and fractures of the frontal skull base from June 1995 to September 2010 at the Turku University Hospital, Turku, Finland, were retrospectively studied. The catchment area is approximately 750 000 inhabitants and Turku University Hospital is its only center treating severe trauma patients. Hospital surgical and discharge registries were used to identify the patients by diagnosis for which, the International Classification of Diseases, 10th edition (ICD-10) codes for skull base fracture and frontal base fracture (S02.10-S02.11) was used. The present study population was identified from this larger cohort of 475 patients by age 18 years and younger.

In the studies of pediatric skull base fractures (Study III) 63 patients were included and in the study of pediatric frontobasilar fractures (Study IV) 20 patients.

The hospital records were reviewed and pertinent details were collected: patient age, sex, type of fracture, trauma mechanism, physical findings at presentation, GCS score, CT imaging, intracranial involvement, treatment and length of stay at the intensive care unit (ICU), synchronous trauma, management of the trauma (conservative or operative), duration of hospital stay and outcome. The GCS score is the sum of three variables on admission: best response on eye opening, best motor response and best verbal response. GCS ≤ 8 indicates severe brain injury, GCS 9-12 moderate brain damage and GCS 13-15 mild brain injury. For the calculation of the trauma incidence the annual number of inhabitants in the health care district was obtained from Statistics Finland (www.tilastokeskus.fi). All patients with intracranial injuries and those who were treated surgically had typically a follow up of at least 6 - 12 months.

In a Study IV, a neuroradiologist reviewed all radiological images of the cranium and the intracranial findings.

4.4.2 Imaging algorithm of frontobasilar fractures (Study V)

This study was a cross-sectional cohort analysis of the radiological data of all patients diagnosed with fracture of the anterior skull base at the Oulu University Hospital, Oulu, Finland, from November 2007 through September 2011 and at the Turku University Hospital, Turku, Finland from June 2010 through October 2011. Twenty-seven consecutive patients (21 male, 6 female; mean age 41,5 years; range 13 to 87, 15 Turku and 12 Oulu) were included. The health care districts included in this study have a population base of approximately 750 000 inhabitants each, and Oulu University Hospital and Turku University Hospital serve as Level 1 Trauma Centers. Hospital discharge registries were used to identify patients with codes for skull base fracture (S02.10-S02.11, International Classification of Diseases, 10th edition, ICD-10). Cranial CT imaging was performed with 64-MDCT scanners (Siemens Somatom, Erlangen, Germany) using a 64 x 0,6 detector configuration and a reconstruction slice thickness of 1,0 mm with 0,7 mm increments. All findings recorded in the primary on-call radiology reports were collected and filed. A review algorithm for analysing CT images of frontobasilar fracture patients was developed to systematically analyze frontal skull base trauma and to assess whether all information necessary for diagnostics and operative treatment planning purposes is present in the primary CT-imaging reports (Table 4). For systematic image reviewing an algorithm, the utilization of MPR reconstruction was recommended and viewing was performed from the frontal vault towards the occiput. If MPR reconstruction was not available, viewing was recommended to start with coronal images while confirming that the image was symmetrical, i.e., that the orbits and maxillary sinuses were symmetrical in coronal images. Axial and sagittal images were used for assessing dislocation of fractures. It was assumed that the position of the patient affected the quality of CT images.

Table 4. Systematic image reviewing algorithm for skull base fractures (coronal, axial and sagittal images).

CORONAL IMAGES FROM ANTERIOR TOWARS POSTERIOR	
- nasal bone	
- frontal sinus*	* attention to nasofrontal ducts, disruption may lead to mucocele formation
- orbits	
ANTERIOR CRANIAL BASE	
- divided into	
1. medial (paranasal sinuses+ethmoid and cribriform plate)	
2. lateral (orbital roofs+lesser wings of sphenoid) and	
3. combined	
- orbital roofs* form base of it	*attention to degree of communition in the lacrimal fossa and attachment of medial canthal tendon to prevent telecanthus
- orbits (maxillary sinus follows the anterior cranial base and	
the orbits in coronal image when the image is scrolled from anterior to posterior direction)	
- crista galli	
- cribriform plate*	*dural tear likely if cribriform plate is fractured
- sphenoid sinus, posterior orbits, maxillary sinus visible on the coronal image	
- apex of orbits, sphenoid sinus, middle cranial fossa	
- optic canal	
- anterior cranial base ends to anterior surface of sella	
MIDDLE CRANIAL FOSSA	
- sella, caudad to sella there is sphenoid sinus	
- carotid canals	
carotid canals* are visible at the level of sella in coronal images	*if disrupted, CTA is needed due to possible disruption or dissection of carotid artery)
- clivus*	*association with high mortality
at the level of the clivus middle and inner ear structures are visible in coronal images	
AXIAL IMAGES FROM CAUDAL TO CRANIAL	
Ideal direction parallel to palate	
- maxillary teeth, corpus of maxilla, pterygoid plates*	*Le Fort I-III fractures
maxillary sinus, nasal septum	
- temporal bone fractures	
→longitudinal or transverse fractures	
- mastoid sinus, inner and middle ear, facial nerve canal	
- zygomaticomaxillary suture, anterior/posterior/medial wall of maxillary sinus	
- anterior and posterior clival wall visible in same image, foramen magnum (basion)	
- zygomatic arches, clivus	
- sphenoid sinus/carotid canals (foramen ovale lies anterior)	
- optic canals	
- ethmoid and sphenoid sinus	
- cribriform plate (axial images are not useful due to parallel direction)	
- frontal sinus	
- axial images are scrolled toward skull vault as far as the fracture is visible	

SAGITTAL IMAGES FROM LATERAL TO MEDIAL
Essential especially when the structure of interest is near midline
- nasal bone
- anterior nasal spine
- hard palate
- frontal bone, frontal sinus (anterior and posterior plates)
- olfactory bulb caudad to roof of sphenoid, cribriform plate continues as a roof of sphenoid (and roof of orbit* continues as a cribriform plate)

* attention to the shape of skull base, as sella follows the anterior skull base and clivus follows the sella

INTRACRANIAL INJURIES
1. pneumoencephalus
2. contusion
3. subdural hemorrhage
4. subarachnoidal hemorrhage
5. intracranial hemorrhage
6. intracranial edema
7. intracranial foreign body

The CT images were systematically reviewed by two experienced emergency and head and neck radiologists and two head and neck surgeons. A workstation and multiplanar reformations of the images were used in the axial, coronal and sagittal plane. Fractures of the anterior skull base were classified into one of three types. 1. Medial type involving the cribriform plate, ethmoid sinus and/or sphenoid sinus. 2. Lateral type involving the orbital roofs and/or lesser wings of the sphenoid bone. 3. Combined fracture involving both the medial and lateral anterior cranial fossa. Fractures of the anterior and posterior wall of the frontal bone were further evaluated by scrutinizing the state of the left-right axis, identification of dislocations and assessment of any fractures in the pterygoid plates and the sphenoid or ethmoid sinuses. The sinuses were examined for the presence of fluid collections. Fractures extending to the sella, clivus and middle cranial fossa were evaluated. In the middle cranial fossa temporal bone fractures were classified as longitudinal or transverse. The type and details of intracranial injury were recorded. Fractures extending to the optic and facial nerve canals and to the vascular channels and injuries to vascular structures were analyzed. Pneumoencephalus and the presence of intracranial foreign bodies were recorded. The findings in the CT images reviewed according to the procedure described above were then compared with the primary CT reports.

4.4.3 Subcranial craniotomy approach for frontobasal fracture correction (Study VI)

Clinical data of all patients diagnosed with frontobasilar fractures during the period from April 1996 to April 2011 at the Turku University Hospital were retrospectively reviewed. Hospital surgical and discharge registries were used to identify the patients according to ICD-10 codes (10th edition) for skull base fractures (S02.10-S02.11) and the surgical procedure codes according to the Nordic Classification of Surgical Procedures for closure of cerebrospinal fistula (AAK40) and for other operations by the cranial base approach (AAE99). The present study population was identified from this larger cohort of 475 patients using the criterion of subcranial craniotomy as the main surgical procedure. A total of 48 consecutive patients (45 male, 3 female, mean age 38,5 years; range 16 to 82 years) were included. The hospital records were reviewed and details were collected on the patients age, sex, socioeconomic status, type of fracture, trauma mechanism, physical findings at presentation, GCS score, CT imaging, intracranial involvement, treatment and length of stay at the ICU, synchronous trauma, details of operative management of the trauma, duration of hospital stay and outcome by GOS (Jennett et al., 1981). GOS was possible to define for 34 patients.

Frontobasilar fractures were classified into four categories: Types I to IV according to the anatomy and pathological intraoperative findings of the trauma (Escher 1969a, Stoll 1993, Stoll 1999). Type I fractures included frontal sinus fractures including either anterior or posterior or both tables, with or without CSF leakage. Type II fractures included fracture of the anterior and/or posterior ethmoid sinus and cribriform plate with or without CSF leakage. Type III fractures included sphenoid sinus injuries with or without CSF leakage and Type IV fractures included fractures of the orbital roof with or without CSF leakage.

An established surgical technique was followed (Raveh and Vuillem 1988a, 1988b, Raveh et al., 1995, 1998, Fliss et al., 1999, Kinnunen and Aitasalo, 2006). Preoperatively, the general condition of the patient and operative indications were evaluated by a multidisciplinary team including an anesthesiologist, neurosurgeon and a neurologist when needed. Under general endotracheal anesthesia a coronal incision was made and skin flaps were raised in supraperiosteal plane. Also the skin lacerations caused by the trauma could be used to expose the surgical area. The flap was elevated anteriorly over the supraorbital ridges and laterally superficicial to the temporal muscle fascia. The supraorbital nerves and vessels were separated from the supraorbital notch. After entrance into the orbits, the anterior ethmoidal arteries were coagulated. An osteotomy to obtain a fronto-naso-orbital block was performed and the osteotomized complex was then removed and stored in physiological saline solution. The traumatic fracture lines could also be used occasionally. Bilateral ethmoidectomy to an extent required or spheno-ethmoidectomy was performed to achieve broad exposure of anterior cranial base. Dural lacerations were sutured and covered by fascia-lata, pericranium or temporal fascia and fixed with fibrin glue. Polyethylene tubes (Portex®, Sims Portex Ltd., Kent, UK) were placed from the frontal sinus to the nasal cavity to provide aeration and re-growth of the sinus cavity mucosa. The bony complex was then repositioned and fixed with either titanium or bioresorbable miniplates and screws. Patients were followed after the injury for approximately 19 months (0 - 110 months). Those not followed at the Turku University Hospital were transferred to another hospital.

4.5 Statistical analysis

In Study I, the data were analyzed with the SAS software (version 6.12) run on a personal computer. The descriptive data were based on univariate lifetime prevalences of dental injuries and crude distributions by the type of injury. The crude relative risks with 95% confidence intervals of the determinants were calculated. Risk ratios (RR) and their 95% confidence intervals (95 % CI) were also stratified by gender. Two-way interactions between the independent variables were checked by the log-linear models. In log-linear models, both dependent variables (dental fractures and luxation or avulsion injuries) were explained by the following independent variables: gender, mental distress, alcohol consumption, malocclusion and previous non-dental injuries. The log-linear models further included the two-way interactions of these independent variables. In the first model, where dental fractures was the dependent variable, once the non-significant interaction terms were reduced, the main effects of the independent variables and the interaction between gender and mental distress were statistically significant. In the second model, where avulsion or luxation injuries were the dependent variables, the main effects of the independent variables and the interaction between retrognathic mandible and previous non-dental injuries were statistically significant. In both models testing was based on likelihood ratio tests (LR-test). These two interactions were taken into account in the results.

In Study II data was analyzed with the SPSS software for Windows, version 10.0 (SPSS Inc., USA). Asssociations among categorical variables were compared between groups, using the χ^2-test as appropriate, independence or proportion test as appropriate. The mean age between the goups was compared using ANOVA or the t-test, as appropriate. The analyses of factors associated with single or multiple fractures and location of injury were carried out using χ^2-test and logistic regression. Odds ratios and their confidence intervals were reported. Since demographic and clinical characteristics varied between the countries, logistic regressions were carried out separately for each country. A probability value of < 0.05 was considered statistically significant and $p < 0.1$ marginally significant.

In a Study III the χ^2-test was used to determine the statistical significance of non-parametric variables between groups. A difference was regarded as significant at probability value of $p < 0.01$.

5 RESULTS

5.1 Prevalence of dental injuries and risk factors (I)

The frequencies and prevalences of dental fractures and dental displacements and avulsions are shown in Table 5. The lifetime prevevalence of dental fractures and avulsions and luxations was 43.3% and 14.3%, respectively. Male participants had more often dental injuries than female participants. A history of previous non-dental injuries, mental distress and high alcohol consumption was positively associated with dental injuries (fractures, luxations and avulsions) as shown in Table 5.

Table 5. Percentages and prevalences of dental fractures (n=2457) and dental displacements and avulsions (n=810) in a cohort of patients aged 31 years. Total prevalence (N=5737) was 43.3% and 14.3%, respectively. The reference group is marked with 1. Crude risk ratios for determinants (RR) and the 95% CI are shown.

	Dental fractures							Luxations and avulsions
Determinants	yes	no	%	RR and 95% CI	yes	no	%	RR and 95% CI
Gender								
female	1087	1885	36.6	1	307	2667	10.3	1
male	1368	1335	50.6	1.38, 1.30-1.47*	503	2193	18.7	1.81, 1.58-2.06*
No other injuries	555	1049	34.6	1	145	1457	9.1	1
Other injuries (non-dental)	1762	2039	46.4	1.34, 1.24-1.44*	612	3186	16.1	1.78, 1.50-2.11*
Mental distress								
HSCL<1.55	1899	2660	41.7	1	594	3959	13.1	1
HSCL≥1.55	529	526	50.1	1.21, 1.12-1.29*	203	853	19.2	1.47, 1.28-1.70*
Alcohol consumption								
non-consumer	233	320	42.1	1	80	474	14.1	1
low or average consumption	1353	20522	39.7	0.94, 0.85-1.05	392	3009	11.5	0.80, 0.64-1.00
-high consumption	839	814	50.8	1.20, 1.08-1.34*	324	1327	19.6	1.36, 1.08-1.70*
BMI								
<25	1431	2005	41.7	1	445	2991	13.0	1
≥25	936	1095	46.1	1.1, 1.04-1.18*	328	1697	16.2	1.25, 1.10-1.43*
Physical Activity								
0-3 times/month	878	1064	45.2	1	294	1643	15.2	1
1-3 times/week	1238	1720	41.9	0.93, 0.87-0.99*	397	2561	13.4	0.88, 0.77-1.02
4-7 times/week	303	396	43.4	0.96, 0.87-1.06	101	599	14.4	0.95, 0.77-1.17
Socio-economic status								
-self-employed	264	303	46.6	1.10, 1.00-1.21*	100	464	17.7	1.25, 1.03-1.53*
-upper-level employee	409	559	42.3	0.99, 0.92-1.08	81	886	8.4	0.59, 0.47-0.74*
-lower-level employee	1349	1833	42.4	1	450	2730	14.2	1
-student	101	112	47.6	1.12, 0.97-1.30	38	174	18.0	1.27, 0.94-1.71
-unemployed	251	316	44.2	1.04, 0.94-1.15	118	450	20.7	1.47, 1.22-1.76*

*p<0.05

The relative risk of dental fractures for patients who had history of non-dental injuries was higher than for patients who had not had previous injuries. The relative risk of luxation and avulsion injuries was similarly higher (Table 5).

Of the participants, 29.5% fell into the category of heavy drinkers and 60.6% were low or average consumers while 9.9% were abstainers. The relative risk of dental fractures among heavy drinkers was higher than among non-users. The same was true for dental luxations and avulsions.

Mental distress was positively associated with a high lifetime prevalence of dental injuries (Table 5). This was seen in dental fractures as well as luxations and avulsion injuries. Genderwise, the relative risk of dental fractures among females was 1.39 (95% CI 1.25-1.54) and among males 1.15 (95% CI 1.05-1.26) (Fig 1A). For dental luxations and avulsions, the relative risks were 1.74 (95% CI 1.39-2.17) and 1.45 (95% CI 1.20-1.75), respectively (Fig 1B).

Dental injuries were common among overweight subject (Table 5). Genderwise, a high BMI increased the risk for dental fractures among female participants. The relative risk for overweight women for dental fractures was 1.11 (95% CI 1.00-1.23) (Fig 1A) and for luxations or avulsions 1.24 (95% CI 0.99-1.57) (Fig 1B).

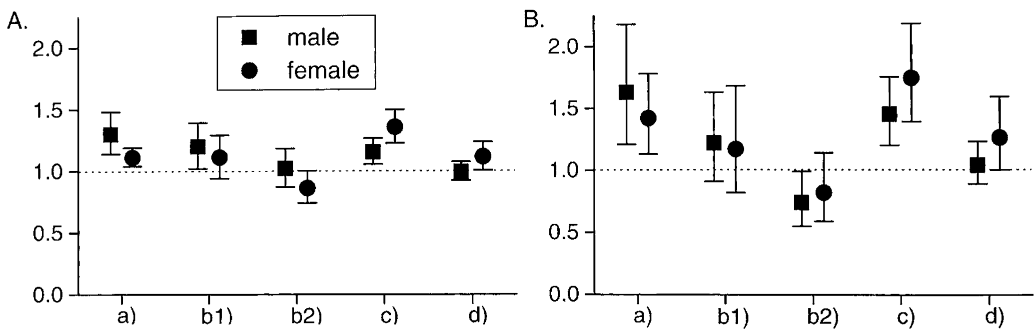


Fig. 1. Risk ratios with 95% confidence intervals for A) dental fractures and B) dental luxations or avulsions. The determinants were a) other injuries (non-dental), b1) high alcohol consumption, b2) average alcohol consumption, c) HSCL ≥1.55 , d) BMI ≥25.0. The determinants in each group are compared to those in the reference groups (Tables 5).

5.5% and 1.4% of the participants reported having retrognathic or prognathic mandible, respectively. A positive association between a retrognathic mandible and dental fractures was observed consistently among participants with a history of previous non-dental injuries (RR 1.56, 95% CI 1.35-1.80). The risk of displacements was 2.62-fold (95% CI 1.98-3.47) among participants with a history of previous injuries and retrognathic mandible. Women with upper incisor protrusion had more often teeth fractures (RR 1.29, 95% CI 1.05-1.59). Among males, there was no statistical difference in this respect (RR 1.05, 95% CI 0.83-1.32). A prognathic mandible had no effect on teeth injuries.

Regular physical exercise (1-3 times/week) was associated with less teeth fractures than exercise 0-3 times/month (Table 5).

The comparison among five socioeconomic groups revealed some differences in the lifetime prevalence of dental injuries among female students who had an increased risk for injuries (Fig. 2A and Fig. 2B). Unemployed subjects and pensioners had an increased risk for dental luxations and avulsions (RR 1.47, 95% CI 1.22-1.76) (Fig. 2B). Upper-level male employees had a decreased risk for luxations and avulsions (RR 0.48, 95% CI 0.35-0.65) (Fig 2B).

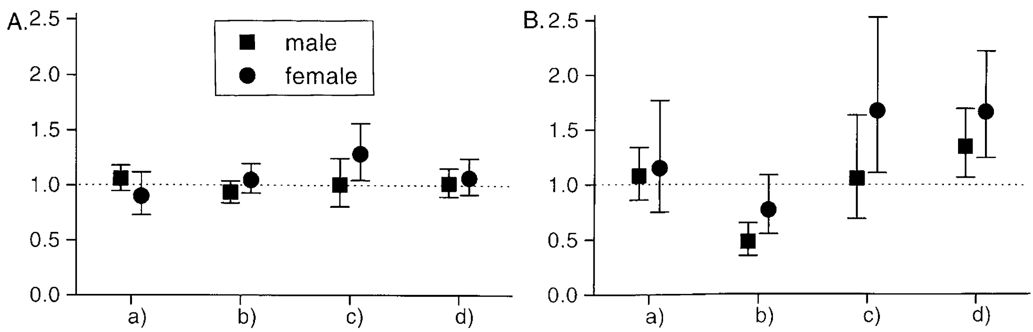


Fig. 2. Risk ratios with 95% confidence intervals for A) dental fractures and B) dental luxations or avulsions. The determinants consisted of the following occupational categories: a) self-employed, b) upperlevel employee, c) student, d) retired/unemployed. The determinants in each group are compared to those in the reference groups (Tables 5).

5.2 Location and multiplicity of mandibular fractures: differences between three countries (II)

The study population consisted of 1552 mandibular fractures sustained by 1092 patients in Canada, Finland and Kuwait, in the 1990's. There were altogether 317 fractures among 228 patients in Canada, 417 among 268 patients in Finland and 818 among 596 patients in Kuwait.

The mean age (±SD) of the patients in Canada was 31.7 (±SD 13.7), in Finland 30.7 (±SD 12.2) and in Kuwait 26.2 (± SD 13.8) years. In Canada, the mean age of patients with mandibular body fractures was lowest while the mean age of those with mandibular ramus fractures was highest. In Finland the mean age was lowest for patients with angular fractures and highest for patients with symphyseal fractures. In Kuwait it was lowest for patients with condylar fractures and highest for patients with ramus fractures (Table 6).

Table 6. Mean age ±SD of the patients with mandibular fractures by anatomic locations in Canada, Finland and Kuwait

Fractures	Canada (n=228)	Finland (n=268)	Kuwait (n=596)	P value
Condyle	29.9±11.9 (136)	33.2±13.8 (143)	22.9±13.6 (162)	<0.001
Ramus	36.3±16.2 (62)	32.6±14.1 (14)	35.1±9.4 (19)	NS
Angle	31.6±14.6 (80)	27.7±11.2 (60)	25.6±11.4 (180)	<0.01
Body	28.5±13.4 (5)	33.5±15.0 (114)	26.9±13.0 (190)	<0.001
Symphysis	34.2±13.6 (34)	34.2±13.1 (86)	25.8±13.3 (204)	<0.001

The difference in fracture location between the three countries was statistically significant in all anatomic locations ($p < 0.01$). Condylar fractures were more common in Canada and Finland than Kuwait. Mandibular angle fractures were more common in Canada than in Kuwait or Finland (Fig 3).

The occurrence of condylar fractures among male patients in Canada, Finland and Kuwait was 64.2%, 48.7% and 27.1% ($p < 0.001$), among female patients 36.8%, 65.8% and 27.5%, respectively ($p < 0.001$). Thus, the proportion of condylar fractures among females was highest in Finland. With the exeption of symphysis fractures in females, the distribution of fracture sites differed statistically significantly in both genders in all three countries.

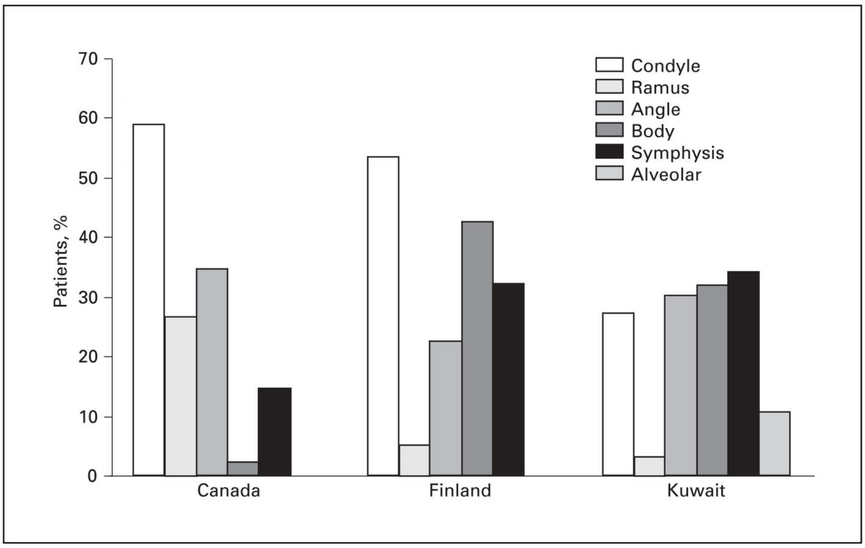


Fig 3. Mandibular fractures by fracture site in Canada, Finland and Kuwait in the 1990’s

Multiple mandibular fractures were more common in Finland than in Kuwait and Canada (p < 0.001) (Table 7). The percentage of multiple mandibular fractures was higher in females than males in all three countries.

Table 7. Comparison of single or multiple fractures in Canada, Finland and Kuwait

	Finland	Canada	P value	Kuwait	Finland	P value	Kuwait	Canada	P value
Single fracture	128 (47.8)	149 (65.4)	<0.001	374 (62.8)	128 (47.8)	<0.001	374 (62.8)	149 (65.4)	0,4882
≥2 fractures	140 (52.2)	79 (34.6)	<0.001	222 (37.2)	140 (52.2)	<0.001	222 (37.2)	79 (34.6)	NS

The etiology of the mandibular fractures varied from country to country. Falls caused condylar fractures in Kuwait and Finland 3.4 times more often than Canada. In Finland RTA was also a major etiological factor for condylar fractures (Table 8). In Canada, males had higher risk of condylar fractures than females; the difference was marginally significant (p < 0.10) (Table 8). In Kuwait multiple fractures were mainly due to falls (Table 9).

Table 8. Etiology, age and gender association with subcondylar, condylar neck and/or intracapsular fractures

Variable	Canada			Finland			Kuwait		
	OR	95 % CI	P value	OR	95 % CI	P value	OR	95 % CI	P value
RTA	0.66	0.14-3.24	NS	4.05	1.45-11.31	<0.01	1.73	0.69-4.37	NS
Violence	1,5	0.42-5.30	NS	1.66	0.62-4.42	NS	1.09	0.37-3.24	NS
Sports	0,69	0.16-2.96	NS	1.15	0.24-5.52	NS	0.58	0.13-2.65	NS
Falls	0.48	0.13-1.76	NS	3.43	1.13-10.46	<0.05	3.41	1.31-8.92	<0.01
Age <20	0.94	0.39-2.28	NS	1.05	0.48-2.31	NS	1.70	0.87-3.29	NS
20-30 years	2.00	0.88-4.57	NS	0.82	0.40-1.71	NS	1.50	0.76-2.98	NS
31-40 years	1.28	0.55-2.98	NS	1.70	0.81-3.60	NS	1.02	0.48-2.48	NS
Male	2.20	0.91-5.35	<0.10	0.62	0.34-1.14	NS	1.19	0.68-2.09	NS

Table 9. Etiology, age and gender association with single versus multiple fracture status in each country

Variable	Canada			Finland			Kuwait		
	OR	95 % CI	P value	OR	95 % CI	P value	OR	95 % CI	P value
RTA	1,1	0.21-5.72	NS	0,84	0.32-2.18	NS	1,98	0.92-4.27	NS
Violence	1,34	0.36-4.94	NS	0,95	0.38-2.39	NS	2,38	0.99-5.72	NS
Sports	0,69	0.14-3.51	NS	0,5	0.12-2.09	NS	1,32	0.40-4.41	NS
Falls	1,63	0.43-6.19	NS	0,77	0.27-2.19	NS	3,59	1.59-8.11	<0.01
Age <20	1,03	0.41-2.57	NS	1,73	0.81-3.72	NS	0,84	0.47-1.51	NS
20-30 years	0,98	0.44-2.22	NS	1,41	0.70-2.84	NS	1,07	0.59-1.95	NS
31-40 years	1,33	0.58-3.07	NS	1,6	0.78-3.28	NS	1,16	0.60-2.22	NS
Male	0,84	0.35-1.99	NS	0,95	0.54-1.70	NS	0,99	0.59-1.66	NS

5.3 Pediatric skull base and frontobasilar injuries, management and outcome (III and IV)

In Study III a total of 63 pediatric patients (37 male and 26 female), mean age 10.7 years (range, 1 - 18 years) fulfilled the entry criteria. The series of pediatric frontobasilar fractures (Study IV) consisted of 20 patients (11 male and 9 female) with a mean age of 12.8 years (range, 6 - 18 years).

The annual incidence of pediatric skull base fractures varied from 0.1 to 1.3 per 100 000 inhabitants. The annual incidence of pediatric frontobasilar fractures during the study period varied from 0.1 to 0.4 per 100 000 inhabitants and from 0.6 to 2.0 per 100 000 children aged ≤ 18 years.

The mechanisms that caused the head trauma leading to skull base fractures are shown in Figure 4. Road traffic accidents (45% versus 38.1% in Study III) were the most common etiological factor causing frontobasilar fractures, followed by being hit by a heavy object (20% versus 6.3% in Study III), violence (15% versus 7.9% in Study III), falling from a height (10% versus 31.7% in Study III) and falling to the ground (10% versus 9.5% in Study III).

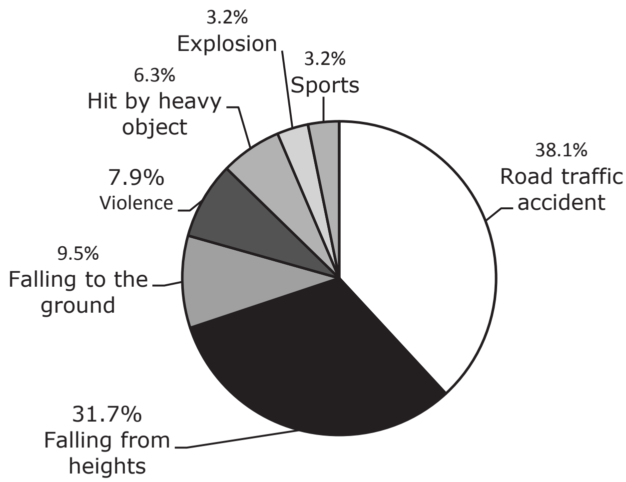


Fig. 4. Percentages of different trauma mechanisms in 63 children with skull base fractures.

The level of consciousness was initially affected three fourths (75 %) of the patients with frontobasilar injury. Among patients with skull base fractures 57% had an effect on their level of consciousness or they were intubated and consequently sedated; 35 % were unconsciouss. The mean GCS for patients with frontobasilar fracture was 10 and with skull base fracture 13. The physical findings at skull base fracture are presented in Table 10.

Table 10. 63 children with skull base fracture: physical findings

Hemotympanum	39/63 (61.9%)
Hearing loss	30/63 (47.6%)
External auditory canal bleeding	29/63 (46.0%)
Tympanic membrane perforation	6/63 (9.5%)
Cerebrospinal fluid leakage	7/63 (11.1%)
-otorrhea	5 (in 2 cases surgical fistula closure)
-rhinorrhea	2 (in both cases surgical fistula closure)
Epistaxis	13/63 (20.6%)
Periorbital ecchymosis	21/63 (33.3%)
Vertigo	10/63 (15.9%)
Facial nerve palsy	3/63 (4.8%)
-temporary	2
-permanent	1
Optic nerve dysfunction	4/63 (6.3%)
-temporary	-
-permanent	4 (2 with complete loss of vision)
Abducens nerve dysfunction	3/63 (4.8%)
-temporary	3
-permanent	-
Olfactory dysfunction	2/63 (3.2%)
-temporary	-
-permanent (partial)	2

Temporary = resolved after surgical treatment or during 3 month follow up

The radiological findings of patients with frontobasilar fractures, and intracranial, maxillofacial and concomitant injuries are presented in Table 11 (III, IV).

In the group of patients with skull base fracture temporal bone fracture was the most common (63.5%) fracture type, followed by fracture through the spheno-ethmoidal complex (41.3%). Almost half of these patients had verified hearing loss (Table 10).

The intracranial injuries in Study IV were re-evaluated and confirmed by a neuroradiologist. In Study III the intracranial injuries were collected from CT reports. In the study of skull base fractures (III) the percentage of intracranial injuries was 42.9% and in the study of frontobasilar fractures that was 60%.

Nearly one fifth (17.5%) of the patients with skull base fracture and 10% with frontobasilar fractures had multiple injuries. Most of these patients were either car passengers or were injured as pedestrians or cyclists hit by a car. Other causes were falling from heights and being hit by a heavy object.

Table 11. Radiological findings, intracranial and maxillofacial injuries in studies III and IV

Injury	III	IV
Fracture of the anterior skull base	14/63 (22.2%)	15/20 (75%)
Orbital roof fracture	NA	8/20 (40%)
-bilateral fractures	NA	5/8 (63%)
-unilateral fractures	NA	3/8 (38%)
Fracture of posterior wall of frontal sinus	NA	9/20 (45%)
Fracture through sphenoid sinus	26/63 (41.3%)	8/20 (40%)
Fracture of sphenoid bone	NA	5/20 (25%)
Fracture of cribriform plate	NA	8/20 (40%)
Fracture of middle skull base		5/20 (25%)
Fracture of temporal bone	40/63 (63.5%)	
Fracture of occipital bone	10/63 (15.9%)	NA
Fracture of parietal bone	7/63 (11.1%)	NA
Fracture through sella	NA	5/20 (25%)
Injury to optic canal	NA	2/20 (10%)
Pneumoencephalus	NA	11/20 (55%)
Carotid canal lesion (unilateral)	NA	5/20 (25%)
Intracranial injury	27/63 (42.9%)	12/20 (60%)
SAH*	1/63 (1.6%)	10/20 (50%)
SDH*	8/63 (12.7%)	4/20 (20%)
ICH*	2/63 (3.2%)	6/20 (30%)
Cerebral contusion	15/63 (24%)	NA
Facial fractures	28/63 (44.4%)	17/20 (85%)
-orbital fractures	22/63 (34.9%)	15/20 (75%)
-maxilla fractures	11/63 (17.5%)	10/20 (50%)
-nasal fractures	12/63 (19%)	8/20 (40%)
-zygomatic fractures	10/63 (15.9%)	7/20 (35%)
-Le Fort III/II	6/63 (9.5%)	5/20 (25%)
-complex naso-orbito-ethmoidal (NOE) fracture	NA	1/20 (5%)
-NOE+maxilla+mandible	NA	1/20 (5%)
Multiple injuries	11/63 (17.5%)	2/20 (10%)
-orthopedic injuries	7/63 (11.1%)	0
-thoracic injuries (lung contusion, tension pneumothorax)	4/63 (6.3%)	2/20 (10%)
-abdominal injuries	2/63 (3.3%)	0

SAH=subarachnoidal hemorrhage, SDH=subdural hemorrhage, ICH=intracranial hemorrhage, NA=not applicable

The management of patients with skull base fracture and frontobasilar fractures is presented in Table 12. In Study IV nearly two thirds of the operated patients had a dural defect, which was closed either with pericranium, temporal muscle fascia, fascia latae or lyophilized dura (Lyoplant®, Bovine Pericardium Dura Substitute, Aesculap

Neurosurgery, B. Braun Melsungen AG, Germany). In Study III 38% of operated patients had dural defect.

Table 12. Management of pediatric skull base (III) and frontobasilar (IV) fractures

	III	IV
Operative treatment	16/63 (25%)	12/20 (60%)
-coronal incision	9/16 (56%)	9/12 (75%)
-fronto-orbital approach		3/12 (25%)
-approach via traumatic lacerations	1	
-mastoidectomy(closure of perilymphatic fistula of inner ear)	1	
-ORIF of mandibular and midfacial fractures+multiple injuries	2	
-other ORIF	3	
Mean duration of surgery	-	2.5 hours
Dural defect	6/16 (38%), of all patients 6/63 (9.5%)	8/12 (67%), of all patients 8/20 (40%)
Polyetylene tubes (Portex®) to maintain frontal recess	8/16 (50%)	8/12 (67%)
Number of patients in ICU	27/63 (43%)	13/20 (65%)
Mean duration of stay in ICU (days)	7.3 (range, 1-30)	5.9 (range, 1-20)
Mean duration of hospital stay (days)	10 (range, 5-69)	17 (range, 3-70)
Number of patients discharged		
-home	54/63 (86%)	16/20 (80%)
-to another institution	8/63 (13%)	3/20 (15%)
Number of deaths	1/63 (1.6%)	1/20 (5%)

Ten out of the sixteen (62.5%) operatively treated patients in Study III had complex frontobasilar fractures of the anterior skull base whereas all patients in Study IV had frontobasilar fractures.

Endocrine problems following head injury and skull base fracture were suspected in two patients (3.2%). One patient had meningitis as a complication of an undiagnosed CSF leakage 3.5 months after the primary operation of a frontobasal fracture. The meningitis led to acute hearing loss and was treated with massive corticosteroids, which further resulted in iatrogenic Cushing's syndrome. The other patient was thought to have growth hormone deficiency, but subsequent investigations proved negative. In Study IV, a single tetraplegic 14-year-old girl developed hirsutism three months after the trauma but endocrinological studies turned out normal. Therefore, except for one patient with iatrogenic Cushings's syndrome, there was no evidence of neither short-term nor long-term neuroendocrine dysfunction.

In Study III, early neurological deficits, varying from dizziness to severe impairment were diagnosed in 21 patients (33.3%). Ten patients (15.9%) had permanent neurological deficits, consisting of moderate to severe neurological or neuropsychiatric disorders. The occurence of long-term posttraumatic sequalae was associated with the value of the GCS score ($p < 0.001$). A GCS score of ≤ 8 was prognostic of a moderate to poor outcome: 80% of the patients whose GCS score was initially ≤ 8 had moderate to severe permanent posttraumatic sequalae, which varied from permanent cranial nerve deficits (permanent loss of vision) to severe disability (permanent vegetative state). In contrast a GCS score ≥ 13 was prognostic of a good outcome: 88% of these patients had no or only mild permanent posttraumatic symptoms varying from enopthalmus to hearing loss and neuropsychological problems. Nevertheless, 12% of the patients with a GCS score of ≥ 13 still had moderate deficiencies.

In Study IV most of the patients (80%) had various adversities, e.g., bone deformity (20%), olfactory nerve dysfunction (10%) and skin abscess (10%). Ophthalmic problems like ptosis, diplopia, telecanthus and enopthalmus occurred in 40% of the patients. Facial neuropathic pain, lacrimal duct dysfunction, soft tissue scarring and persisting rhinitis were sporadically encountered. Two patients developed a postoperative CSF fistula; in one patient this eventually led to meningitis. Both fistulas were successfully closed in a re-operation.

Of the children with skull base fractures, 84% did not develop any permanent neurological or neuropsychological problems following the trauma. The figure for children with frontobasilar fractures was 75%.

5.4 Imaging algorithm for the diagnostics of frontobasilar injuries (V)

The different types of skull base fractures encountered in the primary on-call radiology reports are shown in Table 13A. A fracture of the anterior skull base was present in 93% of the patients but not observed in one third of the patients and thus not reported in the primary radiology reports. In addition, a great majority (13-100%) of accompanying lesions remained initially undiagnosed (Table 13A).

The types of intracranial injuries in primary on-call radiology reports are shown in Table 13B. Ninety-three percent had one or more intracranial injury, all of which had been identified in the primary reports. Still, nearly one third of the subdural and subarachnoidal hemorrhages, 20% of the contusions and 17% of the pneumocephalic lesions were not recorded in the primary reports (Table 13B). One patient had an intracranial foreign body that was not identified as such in the primary report; instead, it was recorded as a comminuted skull impression fracture.

One patient needed an extended CTA because of profuse hemorrhage, an internal carotid artery dissection was identified. Re-evaluation identified fractures through the carotid canal in four patients; these had been missed in the primary reports. As there were no other signs of associated vascular trauma in patients, no other primary CT angiograms were needed.

Table 13. A. Skull base fractures in the primary on-call radiological reports and in the re-evaluated CT images using a systematic imaging reviewing algorithm (N = 27 patients).

Fracture	Fracture in primary report	In re-evaluated images	not diagnosed in primary
Ant.skull base	17	25	32%
Cribriform plate	5	18	72%
Post. wall frontal sinus	10	18	44%
Skull vault	8	16	50%
Ethmoid sinus	20	23	13%
Sphenoid sinus	15	19	21%
Pterygoid plate	5	15	67%
Optic canal injury	1	5	80%
Olfactory bulb injury	0	2	100%
Middle skull base fracture	8	11	27%
Sella	2	9	78%
Clivus	0	2	100%

Table 13.B. Intracranial injuries in primary on-call reports and in re-evaluated CT images using a systematic imaging reviewing algorithm.

Head injury	Injury in primary reports	Injury in re-evaluated images	not diagnosed inprimary reports
Total 27 patients	25	25	0%
Pneumoencephalus	20	24	17%
Contusion	16	20	20%
SDH	11	16	31%
SAH	7	10	30%
ICH	7	10	30%

5.5 Subcranial craniotomy as a surgical approach in frontobasal fractures (VI)

The most common etiology (38%) of the injuries in this study was a road traffic accident, followed by falling from heights (19%), violence (17%), falling to the ground and other etiologies e.g., gun shot or explosion (13%).

Fifteen percent (7/48) were occupational injuries. All patients with occupational injuries were laborers. Three patients had fallen from a height and one was involved in a RTA. Among the other causes were explosion and being hit by an object.

Socioeconomic status of patients is shown in Table 14.

Table 14. Socioeconomic status was available for 41 (85%) patients

Laborers	26/48 (54%)
Unemployed	5/48 (10%)
Lower-level employees with administrative or clerical functions	3/48 (6%)
Student	3/48 (6%)
Upper-level employees	2/48 (4%)
Retired	2/48 (4%)

Table 15. Fracture types and clinical findings at presentation

Type I *	45/48 (94%)
Type II*	28/48 (58%)
Type III*	20/48 (42%)
Type IV*	40/48 (83%)
Intracranial injury	27/48 (56%)
Mean GCS	11
Facial fractures	
-orbital fractures	40/48 (83%)
-maxilla fractures	33/48 (69%)
-zygomatic fractures	25/48 (52%)
-Le Fort III/II	19/48 (40%)
-mandible	7/48 (15%)
Multiple injuries	19/48 (40%)
-orthopedic injuries	16
-compromised airway	10
-thoracic injuries (lung contusion, tension pneumothorax)	9
-abdominal injuries	2
-cervical spine injury	3

*Type I fracture: frontal sinus fracture including either anterior or posterior or both tables, with or without CSF leakage. Type II fracture: fracture of anterior and/or posterior ethmoid sinus and cribriform plate with or without CSF leakage. Type III fracture: sphenoid sinus injury with or without CSF leakage. Type IV fracture: fractures of orbital roof with or without CSF leakage.

The mean GCS was 11 i.e., moderate brain damage (GCS 9-12). Ten patients did not have GCS recorded in their files. Brain damage or some intracranial injury at presentation was diagnosed in 56% of the patients.

CSF leakage was suspected clinically in one fifth of patients. The same figure was recorded for optic nerve injury. Thirty-seven (77%) patients were seen by an ophthalmologist preoperatively. Ten patients had diplopia before the operation. Eighteen (38%) patients were under the influence of alcohol at the time of the injury.

All 48 patients were operated on via the subcranial approach. Endoscopic endonasal procedures or transfacial techniques were not used. The management of frontobasilar fractures is shown in Table 16.

Table 16. Management of frontobasilar fracture patients operated on by subcranial craniotomy

Operative treatment	48/48 (100%)
-coronal incision	48/48 (100%)
Time of surgry after injury (mean)	4.4 days (range, 0-23 days)
Dural defect	31/48 (65%)
-covered by pericranium	21/31 (68%)
-covered by fascia lata	12/31 (39%)
-covered by temporal fascia	2/31 (6%)
-other dural plasty	6/31 (19%)
- Lyoplant®	25/48 (52%)
Aesculap Ag & Co. KG, Tuttlingen, Germany	
- Tachosil®	8/48 (52%)
Takeda Pharmaceuticals International	
GmbH, Zurich, Switzerland	
Polyetylene tubes (Portex®)	45/48 (94%)
- titanium plates	96 %
- resorbable miniplates	12 %
- Bioglass plate	
S53P4, BonAlive® Turku, Finland	21/48 (44%)
Antibiotics	
- ceftriaxone	47/48 (98%)
-clindamycin, metronidazole, glycopeptides	
aminoglycosid or antifungal as add-on	13/48 (27.1%)
Duration of surgery (mean)	3.4 hours
Number of patients in ICU	29/48 (60%)
Mean duration of stay in ICU(days)	8.9 (range, 1-32)
Mean duration of hospital stay(days)	17 (range, 7-39)
Number of patients discharged	
-home	25/48 (52%)
-to another institution	21/48 (44%)
Number of deaths	2/48 (4.2%)

Complications and procedures needed after the subcranial craniotomy are presented in Table 17 and 18.

Table.17. Complications of subcranial craniotomy to correct frontobasilar fracture

Postoperative diplopia	19/48 (40%)
Ptosis	8/48 (17%)
Enopthalmus	13/48 (27%)
Telecanthus	3/48 (6%)
CSF leakage	2/48 (4%)
Meningitis	0/48 (0%)
Frontal sinus mucocele	2/48 (4%)
Olfactory dysfunction	15 (31%)
Nasal congestion	5/48 (10%)
Palpable bony defect	12/48 (25%)
Lacrimal duct dysfunction	4/48 (8%)
Soft tissue scar	7/48 (15%)
Soft tissue fistula	3/48 (6%)
Neuralgia	4/48 (8%)
Pseudoaneurysm	1/48 (2%)

Table 18. Procedures needed after subcranial craniotomy approach (total number of patients who needed further operations was 18, total number of procedures was 25).

Procedure	Number of patients	percentage of re-operated patients
Closure of tracheostomy	5	10 %
Dacryocystoscopy (±stent)	3	6 %
Removal of fixation material	5	10 %
Correction osteotomy	2	4 %
Revision (wound±re-attachment of Portex®)	2	4 %
Strabismus operation	2	4 %
Rhinoplasty	1	2 %
Coil and ligation of pseudoaneurysm	1	2 %
Condylectomy	1	2 %
Closure of CSF fistula by re-operation	1	2 %
Vitrectomy and lensectomy	1	2 %
Tarsorrhaphy	1	2 %

Eighteen (38%) patients needed 25 procedures after the operation (Table 18). Twenty-one (44%) patients were considered to have major complaints and 12 minor complaints after the injury and the operation. The major complaints varied from major neurological or cognitive problems to blindness or total facial nerve paralysis. One fourth of patients did not have any complaints at their last follow-up visit and 35% patients had long-term neurological problems following brain injury. The outcome in terms of GOS is shown in Table 19. GOS could not be established for 14 patients. A great majority of the patients were considered to have recovered well or with moderate disability.

Table 19. Glasgow Outcome Scale (5=good recovery, 4=moderate disability, 3=severe disability, 2=vegetative state, 1=death)

Good recovery	74 %	(25/34)
Moderate disability	21 %	(7/34)
Severe disability	0 %	
Vegetative state	0 %	
Death	6 %	(2/34)

6 DISCUSSION

6.1 General discussion

Reliable epidemiological information on trauma is crucial for decision-making within public health, for identifying factors that increase the risk of injury and for providing targets for preventive measures. Ideally, such information improves the quality of treatment and helps to achieve measures to prevent injuries and morbidity. In this study, epidemiological methods were used to estimate the lifetime prevalence of dental trauma in the general population and to identify the risk factors for dental trauma (Study I). The study consisted of a significant number of participants (5737) aged 31 years – an apparently quite adequate sample of Finnish adults in their thirties. Usually, reports on facial injuries consist of national surveys, although the reasons for facial trauma vary between countries. Study II was conducted to explore the differences in the type and multiplicity of mandibular fractures in three countries Canada, Kuwait and Finland.

Fractures of the skull base are potentially fatal and head injury is one of the leading causes of death in the pediatric age group (Rivara 1999, http://www.cdc.gov/nchs/fastats/lcod.htm.). Our aim in Studies III and IV was to study the management and outcome of pediatric patients with skull base fracture and with frontobasilar fractures. In the study on pediatric frontobasilar fractures (Study IV) CT images were carefully re-evaluated and focused on fracture sites in the skull base and on intracranial lesions. The diagnostic features of frontobasilar fractures of the skull are clinically and radiologically challenging, partly because these fractures are rare, as also seen in this study. A systematic reviewing algorithm, which was presented in Study V, aimed to facilitate the evaluation of CT data to improve the assessment of complex upper midface and skull base trauma. The purpose of Study VI was to review the types of frontobasilar fractures and further, the management, complications and outcome of adult frontobasilar fracture patients treated surgically via the subcranial approach. Detailed information of the current indications and patient selection for subcranial craniotomy and its outcome and complications was needed to improve management decision making for this patient population.

6.2 Methodological considerations

Like the epidemiological cohort study (Study I), Studies II-VI were retrospective. The cohort study (Study I) was part of the Northern Finland Health and Wellbeing Study (Rantakallio 1986), which is a large epidemiological study covering aspects of individual health status and lifestyle from birth to adulthood. Since the information was based on a questionnaire, data was self-reported, professionals statements or dental files were not scrutinized. However, the material may well be considered to be reliable, since the survey covered no less than 5737 participants with extensive previous experience of questionnaires regarding their health over the past years. In general, retrospective data collection offers detailed information for data analysis. Patient records in Finland are accurate and exact, which was to the benefit of the descriptive retrospective studies III, IV and VI. Since not all information is available or reported in patient files, some data, maybe some of it essential, may have been missed.

In studies III and IV it could not be ascertained if all patients with skull base and frontobasilar fractures were ultimately included in the study. The ICD-10 based codes for the skull base and frontobasilar fractures (S02.10-S02.11) were not always necessarily recorded as the primary diagnosis. This is the case with epidural hematoma or other space occupying processes, which may be recorded as the primary diagnosis. Thus, the diagnosis codes used for patient searches may not have been entered in the records. However, the number of cases matched the internal clinic recordings of these fractures. In Study VI not only the ICD-10 codes were used for patient searches but also the surgical procedure codes. The latter codes followed the Nordic Classification of Surgical Procedures for closure of cerebrospinal fistula (AAK40) and for other operations by the cranial base approach (AAE99). Thus, it is very likely that Study VI included all patients treated by subcranial craniotomy.

6.3 Etiological and epidemiological considerations

Estimates of the lifetime prevalence of dental trauma in the general population and the associated risk factors were attained with the use of a large cohort study of 5737 participants aged 31 years (Study I). The lifetime prevalence of dental fractures was 43% and lifetime prevalence of dental luxations and avulsions was 14%. In the literature, the prevalence of dental injuries in the primary dentition is approximately 30% and in the permanent dentition 20% (Andreasen and Ravn, 1972, Glendor et al., 2007). In the permanent dentition, tooth fractures are the most common type of dental injury with prevalences of 26% - 38% (Glendor et al., 2003, Hecova et al., 2010, Lauridsen et al., 2012), whereas luxations dominate in the primary dentition (Glendor et al., 1998). Subluxations predominate also in both the primary and permanent dentition for children (Shayegan et al., 2007). In the present study, it was not possible to differentiate whether the tooth fractures related to the primary or permanent dentition. The respondents were 31 years of age at the time of the inquiry, and it may be assumed that the injuries probably affected the permanent dentition, because not many could have remembered dental injuries years back. Also, some injuries may not have been reported at all, for the same reason. The prevalence of avulsion injuries to the permanent dentition varies according to published reports between 0.5% and 7.1% (Gassner et al., 2003, Andreasen 2007) and of subluxation or luxation injuries between 22% and 48% (Glendor et al., 2003, Hecova et al., 2010, Lauridsen et al., 2012). A prevalence of 14% reported in the present study for both dental luxations and avulsion injuries together is higher for avulsions but lower for luxation injuries. However, the present finding that dental fractures are the most common dental injuries followed by luxation injuries is consistent with previous reports (Diaz et al., 2010, Lauridsen et al., 2012). The exact prevalence of lone luxations or avulsions was not determined in this study.

Male gender is a risk factor for for dental trauma (Petti et al., 1996, Oikarinen et al., 1987, Hecova et al., 2010, Lauridsen et al., 2012) and craniomaxillofacial fractures (Da Silva et al., 2004, Oikarinen et al., 2004, Patrocinio et al., 2005, Bakardjiev and Pechalova 2007, Simsek et al., 2007, Borrman et al., 2009, Lieger et al. 2009, Lee 2009, De Matos et al., 2010, Lee et al., 2010, Thorén et al., 2010, Centers for Disease Control and Prevention 2011, Allareddy 2011). Studies I, III, IV, V and VI show the same. In Study II, gender distribution was not determined but in another article involving the same study population the male to female ratio was 6.5:1 (Oikarinen et al., 2004).

Some people are more often involved in traumatic events than others (O'Mullane 1973, Poole et al., 1997, Sayfan and Berlin 1997, McCoy et al., 2013). In a recent prospective study of 4971 traumavictims, 25% had had an injury before and 75% of these subjects were men (McCoy et al., 2013). The accident-prone subgroup of children with incisor injuries has shown to exist already in childhood (O'Mullane 1973). In Study I, the subjects who had a history of accidents and injuries had also significantly more dental trauma than subjects who had not had accidents before. Persons who experience recurrent injuries, especially injuries due to violent forces may be subjects to their own impulsive and maybe self-destructive behavior. In the present study, personal and social factors affected the occurrence of dental trauma.

The influence of body weight on dental trauma in adults has not been reported previously. In Study I, overweight was positively associated with the increased lifetime prevalence of dental injuries and regular physical activity seemed to reduce the risk for dental fractures. Similar results were reported from a study on dental trauma in obese children (Petti et al., 1997): one third of overweight children had experienced a dental trauma compared to one fifth non-obese control subjects. The difference might be due to clumsiness induced by increased body weight. On the other hand, obese subjects are less active, and an active lifestyle could protect against trauma (Petti et al., 1997), which was concluded in the present series. In a Brazilian study of 1046 schoolboys, there was, again, no correlation between dental injuries and obesity (Soriano et al., 2009). Study I shows that physical factors such as overweight and physical activity do affect a person's predisposition to dental injuries.

Accidents are often related to alcohol use and abuse (Poole et al., 1997, Mura et al., 2003, McCoy et al., 2013). High alcohol consumption was associated with dental fractures, luxations and avulsions: 10% of patients with pediatric frontobasilar fractures (Study IV) and 38% of patients with frontobasilar fractures treated by subcranial craniotomy (Study VI) were under the influence of alcohol when treated acutely. In Studies II and III the role of alcohol was not studied. Alcohol is related to 15% of mandibular fractures in Finland and in 21% of cases in Canada (Oikarinen et al., 2004). In a recent epidemiological study of maxillofacial fractures, 15% of patients were intoxicated, usually (91%) due to alcohol consumption (van Hout et al., 2012). Mental distress was positively related to a high lifetime prevalence of dental injuries (Study I). This finding is consistent with the literature, which reports that pre-existing psychopathology, especially alcohol abuse, is common among trauma patients (Whetsell et al., 1989, McCoy et al., 2013).

The socioeconomic status of a person affects the lifetime prevalence of dental injuries (Study I). Female students had an increased risk for dental injuries. High socioeconomic status in male subjects reduced the risk of dental luxations and avulsions, whereas unemployment and retirement increased the risk for luxation and avulsion injuries in both genders. A high prevalence of unemployment is related to an overall accident proneness (Poole et al., 1997, McCoy et al., 2013). In Study II, the fall injuries in Kuwait were common causes of multiple mandibular fractures and mandibular condyle fractures. Falling from a height as consequence of deficient safety equipment in construction sites was discussed and was a serious occupational health issue and a source of concern in Kuwait in the 1990's (Oikarinen et al., 2004). The socioeconomic aspects were taken into account again in the study of 48 adult frontobasilar fractures treated by subcranial craniotomy (Study VI). Here, every seventh injury was an occupational injury. All patients with occupational injuries were laborers. In a Swiss study there were 42 patients with occupational maxillofacial injuries (Eggensperger et al., 2006). That study concluded that farm and forestry workers have a 127-fold risk and construction workers have a 44-fold risk of maxillofacial fractures compared with service and office workers. In their study 24% of the fractures involved the skull base, orbital roof and anterior frontal sinus (i.e., frontal base area), but in the present study all were frontobasilar fractures. The percentage of occupational injuries in that study was 8.4%. In the present study the proportion was 15%, but the injuries were clearly more complex in the present study. According to previous reports, the percentage of occupational injuries among patients who sustain facial fractures is 4.5% to 5% (Iizuka et al., 1990, Gassner et al., 2003) and anterior cranial base fractures 7% (Scholsem et al., 2008). In the light of these studies the percentage in the present study was higher. The higher percentage in the present study may be fortuitous, since the group of occupational injuries was small.

The epidemiology of maxillofacial fractures is heterogeneous because of different cultural, socioeconomic and environmental conditions for different populations (Zix et al., 2011). RTA's and violence are the main causes for mandibular fractures worldwide. The etiology of mandibular fractures varied between the three countries in Study II. The etiology affects the pattern of injury, i.e., the site of the fracture is associated with the cause (Rashid et al., 2013). Condylar and angle fractures are often caused by violence, e.g., when a fist strikes the recipient's face. Violence is a major cause for mandibular fractures in Canadian men (Oikarinen et al., 2004). Accordingly condylar fractures were more common in Canada and Finland than Kuwait, and this was most apparent among Canadian male patients in the present study. Also mandibular angle fractures were more common in Canada than in Finland or Kuwait. In Finland, RTA’s and falls were the two major etiological factors related to condylar fractures. This finding is in agreement with previous studies (Zix et al., 2011). In Kuwait the cause for these fractures was mostly falls. These numbers are consistent with the recent study from London, which reported that angle fractures were often caused by violence (36%) whereas condylar fractures were caused by falls (53%) and RTA’s (28%) (Rashid et al., 2013). Multiple fractures are often the consequence of high-energy impact, such as RTA’s. In Canada, Finland and Kuwait females had multiple mandibular fractures more often than males, which is a source of concern and should raise discussions not only the role of traffic safety but also of domestic violence.

RTA’s generate a high-energy impact and cause upper-facial fractures, which further are associated with high morbidity and even mortality. In the present series of studies of skull base (III) and frontobasilar fractures (IV and VI), the most common etiological factor was RTA (in studies III 38.1%, IV 45%, 37.5%). The finding is in accordance with a previous study on frontobasilar fractures in children (Thorén et al., 2011). In another study on pediatric craniofacial trauma, falls were the major etiological factor (Eggensperger Wymann et al., 2008). In the present series falling from heights was the second most common cause of injury in children with skull base fractures (Study III) and in adults with frontobasilar fractures (Study VI). High-energy injuries explain the high percentage of brain damage (in Studies III 42.9 %, IV 60 %, V 93 %, VI 56 %, respectively) and associated multiple trauma (in Studies III 17.5 %, IV 10 %, VI 40 %), which are well known from the literature (Madhudusan et al., 2004, Follmar et al., 2007, Scholsem et al., 2008, Bell and Chen, 2010). Synchronous or multiple trauma entails injury in extremities, airway problem, lungs, pelvic fracture or cervical-spine injury. The percentages of associated injuries in craniomaxillofacial fracture patients in the literature vary from 25% to 53% and depend on the sustained energy impact (Follmar et al., 2007, Thorén et al., 2010). In a Swiss study of pediatric frontal skull base injuries, no less than 91% of the children had associated injuries, skull vault fractures being the most common (85.7%), followed by brain (59%) injury (Schaller et al., 2012). Skull vault injury was not considered to be an associated injury in the present studies. There were also other differences in the prevalence of associated injuries between the Swiss report and Study IV; facial injuries 43% vs 85%, thorax injuries 20% vs 10% and abdominal injuries 8% vs 0% in the Swiss study vs Study IV, respectively. The prevalence of brain injuries in connection with anterior skull base trauma in the Swiss study was similar (59%) to that of Study IV (children) and Study VI (adults) (56-60 %).

6.4 Diagnostic considerations

Fractures of the frontal base are often complex and identification of the anatomical landmarks may be difficult. Early evaluation of skull base and frontobasilar fractures is essential for identifying, treating and preventing possible complications, such as CSF leakage with a risk for meningitis, vascular injuries, compression of the optic or oculomotor nerves and defects of other cranial nerves (cranial nerves I, IV-VI). The diagnosis of frontal base fracture is based on clinical examination and imaging. The high prevalence of associated intracranial injuries among patients with frontobasilar and concomitant facial fractures warrants early evaluation, treatment and multidiscliplinary collaboration, which includes neurosurgical consultation.

There are several classifications and algorithms for the diagnostics and management of craniofacial and anterior skull base fractures (Escher 1969a, 1969b, Raveh et al., 1992, Asano et al., 1995, Burstein et al., 1997, Donat et al., 1998, Sakas et al., 1998, Buitrago-Tellez et al., 2002, Meco et al., 2002, Smith et al., 2002, Madhusudan et al., 2004, Chen et al., 2006, Manson et al., 2009, Echo et al., 2010). The ideal craniofacial classification system should be systematic, include different fracture patterns and it should provide information on injury severity and advice on treatment (Buitrago-Tellez et al., 2002). In order to exploit all relevant diagnostic information in CT images for planning and operative treatment, a systematic image-reviewing algorithm was developed for craniomaxillofacial surgeons and radiologists (Study V). Classification of anterior skull base injuries in the algorithm was done together with neuroradiologists and it was different from the classification used in studies III-IV and VI. It was based on relevant anatomical landmarks in viewed CT images. Fractures of the anterior skull base were classified as one of three types: a medial type, a lateral type and a combined type. Although Burstein et al. (1997) divided frontobasilar fractures into central, unilateral (including supraorbital rim and upper lateral rim like in lateral type in Study V) and bilateral (combined in Study V) types, the classifications are not identical. Their classification (Burstein et al., 1997) was intended for planning of elective orbital and cranial osteotomies (for access to the anterior skull base and orbital apices). This allowed simultaneous reconstruction of fracture fragments by the trauma team and dural tear repair by the neurosurgical team. The classification used in the Studies III-IV and VI is simple and based on modification of Escher's classification from 1969; it takes into account the anatomy and intraoperative findings, such as CSF leakage (Escher 1969a, 1969b, Stoll, 1993, Stoll, 1999, Hardt and Kuttenberger, 2010). Fracture types I-IV include the frontal sinus, the ethmoid sinus and cribriform plate, the sphenoid sinus and the orbital roof. All types are with or without CSF leakage.

In Study V the CT images were systematically viewed on a workstation with multiplanar reformations of the images with an aid of a novel algorithm. This algorithm allowed simultaneous review of the anatomic information of the anterior and middle cranial fossa in the anterior-posterior direction. The type and details of intracranial injury were also recorded. The primary CT assessment of 27 patients diagnosed with a frontobasal fracture was compared with the reassessment of the same data using the novel systematic CT-image reviewing algorithm. The systematic use of the algorithm helped to detect fractures and other craniomaxillofacial lesions that were missed in the primary reports by on-call radiologists. Similar use of algorithms is not found in the previous literature. Similar to check-list used in operating theaters, an image-viewing algorithm standardizes the frontobasal trauma detection procedure and leads ideally to better control and assessment of complex anterior skull base fractures. Algorithms can further be used as a tool for training and management of these injuries by physicians in training.

6.5 Management and outcome

The management of frontobasilar fractures depends often on accompanying lesions, e.g., intracranial injuries, dural tears and CSF leaks rather than on the fracture itself. The mean GCS of 10 and 11 in Studies IV and VI on frontobasilar fractures suggests moderate brain damage (indicated by GCS 9 to 12), whereas the mean GCS score of 13 in the pediatric skull base study indicates mild brain damage (indicated by GCS 13 to 15). GCS ≤ 8 suggests severe brain damage (Teasdale and Jennett, 1974). The severity of traumatic brain damage may not be determined by the GCS on admission alone. Several other factorors, e.g., duration of unconsciousness, duration of loss of memory, neurological deficits following trauma and radiological findings of brain injury on CT or MRI may also be useful when severity of TBI is assessed. Loss of consciousness (LOC) was evident in 75% of the pediatric patients with frontobasilar fractures (Study IV) and in 35% of pediatric patients with skull base fractures (Study III). The presence of LOC alone increases the risk of significant intracranial injury from 0% to 4% and moves the patient from a low-risk group to a moderate-risk group (Masters et al., 1987). Subarachnoidal bleeding predicts a poor outcome (MRC CRASH Trial Collaborators 2008). SAH was assessed and confirmed in two of the present series (Studies IV and V) by a neuroradiologist reviewing the CT images. SAH signifies severe brain injury and occured in 50% of the children with frontobasilar fractures (Study IV) and in 37% of the adults with frontobasilar fractures (Study V). Traumatic acute subdural hematomas (SDH) are rather common in young children and the incidence decreases toward adolescence. The outcome of patients with subdural hematoma is worse than with epidural hematoma (Hahn et al., 1988, Kumar et al., 2009). In the pediatric studies III and IV, the prevalence of SDH was 13% and 20%, respectively. The numbers differ slightly but they are still consistent with the literature. In a series of 96 children with severe brain injury (Jagannathan et al., 2008) 68% had subarachnoidal hematoma and 23% subdural hematoma. Although the severity of brain damage was not assessed in the present studies these parallel figures from the literature gives an indication of the severity of brain damage of the patients.

Every fourth child with a skull base fracture (Study III) and 60% of the children with a frontobasilar fracture (Study IV) were treated operatively. Surgical treatment is appropriate for severely displaced fractures according to general surgical principles with reduction and fixation respecting the impact to the growth in children. Three fourths of the children in Study IV and all adult patients in Study VI were operated on by the subcranial craniotomy approach. The subcranial approach allows wide exposure to the anterior skull base below the traditional transfrontal approach and it presents an easy access to simultaneous repair of dural defects and to decompression of the optic nerve without extensive manipulation of the frontal lobe (Fliss et al., 2007). Moreover, the facial incisions and consequent scars can be avoided using the coronal incision and morbidity is generally speaking low (Raveh et al., 1995, Fliss et al., 1998, Kellman and Marentette, 2001, Hendryk et al., 2004). This was consistent with the findings on Study VI: the subcranial technique turned out to be an feasible one-stage approach for fractures of the anterior cranial base, which require open reduction due to their comminution and complexity. The rate of significant morbidity was rather low and the results can be considered good. Although transnasal endoscopic techniques have recently gained popularity, an open approach still is acceptable for the treatment of multiple fractures or fractures involving nerve lesions (Kirtane et al., 2005, Scholsem et al., 2008, Liu, 2010).

A CSF leak is a sign of communication from the contaminated paranasal sinuses to the sterile intracranial space and this poses a risk for potentially life-threatening conditions, such as meningitis and brain abscess (Bullock et al., 2006, Scholsem et al., 2008, Van de Beek et al., 2010, Horowitz et al., 2011). The incidence of meningitis following skull base fracture may be as high as 32% and the risk increases when CSF leakage persists (Baltas et al., 1994, Choi et al., 1996, Daudia et al., 2007). In a large study from the US Nationwide In-patient Sample Database, 7.7% of the patients with CSF rhinorrhea developed meningitis (Sonig et al., 2012). In Studies III, IV and VI dural tears, in other words potential pathways for bacteria to the intracranial space, were present peroperatively among 9.5%, 40% and 65% of the patients, respectively. Two patients (10%) with a frontobasilar fracture (Study IV) had postoperative CSF fistulas, which eventually led to meningitis in one of the patients. The same patient was the one with meningitis in the skull base fracture group giving prevalence of 1.6%. In Study VI two patients (4.2%) had postoperative CSF leaks but neither developed meningitis. Meningitis occurred in 5% of the pediatric patients with frontobasilar fractures, which is consistent figure with the study by Scholsem et al. (2008) comprising 109 patients with anterior cranial base fracture associated CSF leak where meningitis occurred in 4.6% of the patients. Comminuted anterior cranial base fractures were operated on by a combined intradural and extradural repair approach (Scholsem et al., 2008). Ten percent had a postoperative CSF fistula, which is in accordance with the rate in Study IV but higher than in Study VI, i.e., among patients with a frontobasilar fracture (4.2 %). If a fistula was detected it was closed either via intracranial or transsphenoidal exploration. Although 65% of the patients had peroperatively exposure or a defect of the dura due to bone dehiscence (Study VI), only two patients (4.2%) had a CSF fistula following surgery and no one had meningitis. As mucoceles from the frontal sinus mucosa may develop up to 50 years after the trauma (Mourouzis et al., 2008), long follow-up times are warranted. In the present series (Study VI) 4% had a frontal sinus mucocele four and ten years after the trauma.

The long-term posttraumatic sequalae were related to GCS scores in children with skull base fractures. A GCS score of ≤ 8 was prognostic for a moderate to poor outcome, as 80% of the patients, whose GCS score was initially lower than 8 had moderate to severe permanent posttraumatic sequalae. In contrast, a GCS score ≥ 13 was prognostic for a good outcome as 88% of these patients had no or mild permanent posttraumatic symptoms. Yet, 12% of the patients with a GCS score ≥ 13 still had moderate impairment (Study III). The correlation between GCS ≤ 8 and poor outcome is consistent with the previous studies (Yilmazlar et al., 2006, Lee et al., 2012). The level of consciousness at the onset, the presence of intracranial injury and an associated CSF fistula in patients with a skull base fracture have been considered to be predictors of a poor outcome (Yilmazlar et al., 2006). However, an initially low GCS score (<5) does not automatically predict poor late outcome in children and a good functional outcome is fully possible also for these patients (Jagannathan et al., 2007, Thomale et al., 2010).

The outcome in Study VI evaluated by GOS was essentially similar to what was reported by Scholsem et al. (2008) and Deb et al. (1998). In Study IV, 74% were considered to have recovered well at the last follow-up visit and one fifth (21%) had moderate disability. However, 1-2.9% of the patients were reported to have severe disability by Scholsem et al. and Deb et al. whereas none in Study VI was considered to have severe disability. Higher prevalences of head injury might have contributed to this difference between their studies and the present series of studies (Scholsem et al., 2008, Deb et al., 1998). Similarly, mortality was less in the present series of studies than reported before and significantly less than what is generally associated with severe head trauma in children, i.e., 20% - 50% (Ort et al., 2004, Thomale et al., 2010, Sookplung and Vavilala 2009).

Based on the present series of studies both skull base fractures and frontobasilar fractures are rare injuries in childhood. Although these traumas are associated with intracranial injuries and long-term morbidity, mortality is uncommon. Indeed, although early neurological deficits caused by traumatic brain injury were observed in 33% of the children with skull base fracture, only less than one fifth had permanent neurological or neuropsychiatric disorders. In other words: a great majority of children with a skull base fracture do not have permanent neurological problems. This is well in line with a report of frontobasilar fractures in children (Study IV), in which 40% had various long-term sequalae but 75% of the patients showed no permanent neurological or neuropsychological sequelae. Adults seem to recover more poorly: 35% of the adult patients with frontobasilar fractures had permanent neurological problems following brain injury at the last follow-up visit (Study VI). This is consistent with a large study from the United States according to which 43% of 288,009 in-patient TBI victims had long-term disabilities (Selassie et al., 2008). In studies with children, a good functional outcome is seen in up to 82% of patients with a severe brain injury (Jagannathan et al., 2007, Thomale et al., 2010).

6.6 Limitations of the study

In Study I the material consisted of the participants' subjective views, not of statements by professional people or dental charts and only self reports were obtained. It was not possible to specify whether there had been single or multiple tooth injuries. The cause, type and severity of injury remained unknown. The overall incidence of dental trauma could not be defined from these files. The classification of malocclusions into retrognathia and prognathia was also based on the patients' own view. Due to cohort design of the study, the study presented only 31-year old adults. A rather large number (2726) of potential participants did not participate in the study.

Assessment of outcome in Studies III, IV and VI by recording permanent neurological deficits at the last follow-up visit and by GOS (Study VI) is debatable. According to the literature, the severity of brain injury determines largely patient outcomes (Yilmazlar et al. 2006). The GOS was initially designed for the assessment of outcome following severe head injury (Jennett and Bond, 1975). However, it has also been used for the evaluation of outcome after mild brain injury (Deb et al., 1998). The severity of brain dammage in the present series of studies was not assessed. The presence of permanent neurological deficits was also concluded from retrospective patient files by the authors, not directly by an interdisciplinary team or by an independent neuropsychiatric team.

Patients and results in Studies III, IV and VI were purely from southwest Finland. Furthermore, due to a rare trauma type and consequent small sample series, the overall generalization of conclusions to the whole population is limited. Hence, it is debatable whether this kind of sampling with a reasonably small sample size is sufficient or suitabable for epidemiological studies (Andersson and Andreasen, 2011). Although retrospective analyses of patient data is rather reliable in Finland where hospital charts contain accurate and sufficient data, not all information is available or it is not reported to the patient files.

6.7 Future considerations

The possible neuroendocrine sequalae were initially of special interest in Study IV, which examined frontobasilar fractures in children. Pituitary function was poorly screened and there were no clinically evident short-term disorders. This was also true for patients with a radiologically detected injury of the sellar or hypophyseal area. Endocrine problems following head injury and skull base fractures were suspected in three pediatric patients but only one of them had eventually an endocrinological diagnosis (Studies III and IV). Partial or complete post-traumatic hypopituitarism (PTHP) can affect one third to half of the patients with TBI (Zaben et al., 2013). PTHP is not necessarily related to the severity of TBI, i.e., patients with even mild TBI can also be at risk. PTHP is not easy to diagnose since symptoms are nonspesific (fatigue, cognitive difficulties, myopathy, depression and behavioral changes), but may all be symptoms of TBI or concussion as well.

In this series an association between PTHP and TBI was not evident: life-threatning situations e.g., adrenal crisis and dysregulation of sodium, were not encountered and there were no symptoms that would have required further hormonal investigations on a regular basis. A group of specialists (Ghico et al., 2005) have made a consensus statement in 2005 stating that all the patients admitted for mild to severe TBI should have basal hormonal testing if they have symptoms of hypotension or hyponatremia. They should also be screened 3 and 12 months after the injury. Because of the frequency of TBI-associated hypopituitarism, maybe in future all patients with traumatic brain injury or post concussion syndrome is to be screened so that outcome improves and disability decreases. This is particularly pertinent for otorhinolaryngologists and head and neck surgeons treating patients with anterior skull base fractures because they are less familiar with brain injuries and their possible neuroendocrine sequalae than e.g., neurosurgeons. Further studies on specifically these aspects might be needed.

In these studies, endoscopic endonasal repair of CSF fistulas, which have gained worldwide success in previous years, was not included in the studies. In the future it would be of interest to evaluate the patient selection, management and outcome of endoscopically repaired CSF fistulas in frontobasilar fractures. Research is also needed on the utilization of CAS-equipment in the treatment of these fractures.

A substantial number of TBI patients experience long-term neuropsyhcological problems, e.g. depression, irritability, sleep disorders and impatience (Deb et al., 1998, Kim et al., 2007). As these aspects were not included in the present series of studies, it would be of interest to further examine the neoropsychological outcome. Such a study could be conducted as a multicenter study to secure a sufficient sample size.

7 CONCLUSIONS

1. The lifetime prevalence of dental fractures was 43% and the lifetime prevalence of dental luxations and avulsions was 14%. Male gender, history of other injuries, overweight, mental distress and high alcohol consumption were positively associated with the frequency of dental injuries. Regular physical exercise decreased the risk for dental fractures. Thus, personal, social and physical factors affect the occurrence of dental injuries.

2. In Finland condylar fractures were caused by road traffic injuries and falls. Falls were a common cause of multiple mandibular fractures and mandibular condyle fractures in Kuwait. A conclusion of the study was that differences in mandibular fracture multiplicity and location are based on different etiologies and demographic patterns.

3. The conclusions of the studies were, that skull base fracture and frontobasilar fracture are both a rare injury in childhood. These traumas are associated with intracranial injuries and long-term morbidity, but mortality is uncommon. Although morbidity is frequent following skull base and frontobasilar fractures, permanent neurological or functional deficits are infrequent.

4. The systematic use of the algorithm helped to detect fractures and other craniomaxillofacial lesions that were missed in the primary reports made by on call-radiologists. The conclusion from that study was that a check list similar to what is used in operating theatres for image-viewing standardizes the procedure to detect frontobasal trauma on images, leading to better control and assessment.

5. The subcranial approach seemed to be successful for the management of all frontobasilar fractures in this series with a reasonably low complication rate. Therefore, we recommend subcranial craniotomy as described here technique of choice in multiple and even in the most complicated frontal base fractures.

8 ACKNOWLEDGEMENTS

This study was carried out at the Department of Otolaryngology-Head and Neck Surgery, University of Turku and Turku University Hospital and at the Institute of Dentistry, Department of Oral and Maxillofacial Surgery, University of Oulu during the years 2000-2014.

I express my gratitude to Professor Reidar Grénman, Head of the Department of Otolaryngology-Head and Neck Surgery for a supportive scientific atmosphere and for allowing me the time to conduct this work.

I owe my deepest gratitude to my supervisors, Professor Antti Mäkitie and Adjunct professor Ilpo Kinnunen, for excellent guidance and encouragement during these years. I thank them both for always finding time for me and my numerous questions. I am honored to have been able to work under your guidance.

I am grateful to Professor Kyösti Oikarinen for his enthusiasm in giving me the initiative for the study of maxillofacial trauma.

I owe my sincere thanks to Adjunct professor Hanna Thorén and Professor Markus Rautiainen, for their constructive criticism and valuable comments for the improvement of this manuscript. I thank Adjunct professor Robert Paul, Cert.Transl., for his language review.

I am grateful to all my co-authors, especially Professor Kalle Aitasalo, Professor Roberto Blanco Sequeiros, Adjunct professor Petri Koivunen and Dr. Jari Karhu, MD, for fruitful collaboration and expertise.

I thank my former and present colleagues and the staff at the Department of Otorhinolaryngology-Head and Neck Surgery, Turku University Hospital for a friendly and stimulating working atmosphere.

I sincerely thank all my friends mainly in Turku, Helsinki and Oulu for innumerable enjoyable moments, conversations and for sharing the ups and downs of life during these years. Your friendship has always been and will be very important to me despite the hectic times, often workwise, that have not allowed me to meet you properly.

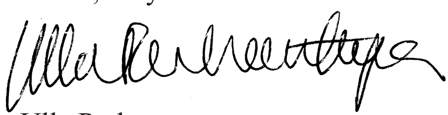
I warmly thank my mother Eija and my father Tapio and his lovely spouse Seija for the love, care and support you have showed to me. I also thank Henkka and Perttu, and Erkki with his family, for being in my life.

I devote my deepest affection to my precious daughters, the true sunshines of my life, Vilma and Emppu. Thank you for being there. Through you I know what is most valuable in my life.

Finally, I owe my warmest thanks to Vesa for his encouragement and patience during the final stages of this thesis.

This work was financially supported by the Finnish Medical Foundation, the Foundation of the Finnish Otorhinological Society, the Finnish Association of Oral and Maxillofacial Surgeons and grants from the Turku University Hospital (EVO) and the University of Turku.

Turku, May 2014



Ulla Perheentupa

9 REFERENCES

Algin O, Hakyemez B, Gokalp G, Ozcan T, Korfali E, Parlak M. The contribution of 3D-CISS and contrast-enhanced MR cisternography in detecting cerebrospinal fluid leak in patients with rhinorrhea. Br J Radiol 2010; 83: 225-232.

Allareddy V, Allareddy V, Nalliah RP. Epidemiology of facial fracture injuries. J Oral Maxillofac Surg 2011; 69: 2613-2618.

Alonge OK, Narendran S, Williamson DD. Prevalence of fractured incisal teeth among children in Harris County, Texas. Dent Traumatol 2001; 17: 218-221.

Andreasen JO, Ravn JJ. Epidemiology of traumatic dental injuries to primary and permanent teeth in a Danish population sample. Int J Oral Surg 1972; 1: 235-239.

Andreasen JO, Andreasen FM, Andersson L. Textbook and color atlas of traumatic injuries to teeth, 4th ed. Oxford, Blackwell-Munksgaard; 2007. p. 217-254.

Andersson L, Andreasen JO. Important considerations for designing and reporting epidemiologic and clinical studies in dental traumatology. Dent Traumatol 2011; 27: 269-274.

Ardekian L, Gaspar R, Peled M, Manor R, Laufer D. Incidence and type of cervical spine injuries associated with mandibular fractures. J Craniomaxillofac Trauma 1997; 3: 18-21.

Antimicrobial prophylaxis in neurosurgery and after head injury. Infection in Neurosurgery Working Party of the British Society for Antimicrobial Chemotherapy. Lancet 1994; 344: 1547-1551.

Arrer E, Meco C, Oberascher G, Poitrowski W, Albegger K, Patsch W. Beta-Trace protein as a marker for cerebrospinal fluid rhinorrhea. Clin Chem 2002; 48: 939-941.

Asano T, Ohno K, Takada Y, Suzuki R, Hirakawa K, Monma S. Fractures of the floor of the anterior cranial fossa. J Trauma 1995; 39: 702-706.

Avery LL, Susarla SM, Novelline RA. Multidetector and three-dimensional CT evaluation of the patient with maxillofacial injury. Radiol Clin North Am 2011; 49: 183–203.

Bakardjiev A, Pechalova P. Maxillofacial fractures in Southern Bulgaria-A retrospective study of 1706 cases. J Craniomaxillofac Surg 2007; 35: 147-150.

Baltas I, Tsoulfa S, Sakellariou V, Vogas M, Fylaktakis A, Kondodimou A. Post-traumatic meningitis: bacteriology, hydrocephalus and outcome. Neurosurgery 1994; 35: 422-426.

Bank CA, Palmer JN, Chiu AG, O'Malley BW Jr, Woodworth BA, Kennedy DW. Endoscopic closure of CSF rhinorrhea: 193 cases over 21 years. Otolaryngol Head Neck Surg 2009; 140: 826-833.

Barest GD, Mian AZ, Nadgir RN, Sakai O. Traumatic and non-traumatic emergencies of the brain, head and neck. In: Soto J, Lucey B (eds.) Emergency radiology, the requisities. Philadelphia, Elsevier/Mosby; 2009. p. 1-60.

Baumann A, Ewers R. Midfacial degloving: an alternative approach for traumatic corrections in the midface. Int J Oral Maxillofac Surg 2001; 30: 272-277.

Beckhardt RN, Setzen M, Carras R. Primary spontaneous cerebrospinal fluid rhinorrhea. Otolaryngol Head Neck Surg 1991; 104: 425-432.

Bell RB, Dierks EJ, Homer L, Potter BE. Management of cerebrospinal fluid leak associated with craniomaxillofacial trauma. J Oral Maxillofac Surg 2004; 62: 676-684.

Bell RB, Dierks EJ, Brar P, Potter JK, Potter BE. A protocol for the management of frontal sinus fractures emphasizing sinus preservation. J Oral Maxillofac Surg 2007; 65: 825-839.

Bell BR, Chen J. Frontobasilar fractures: contemporary management. Atlas Oral Maxillofac Surg Clin N Am 2010; 18: 181-196.

Bormann K-H, Wild S, Gellrich N-C, Kokemuller H, Stubmer C, Schmelzeisen R, Schön R. Five-year retrospective study of mandibular fractures in Freiburg, Germany: incidence, etiology, treatment and complications. J Oral Maxillofac Surg 2009; 67: 1251-1255.

Borssen A, Holm AK. Traumatic dental injuries in a cohort of 16-year-olds in northern Sweden. Endod Dent Traumatol 1997; 13: 276–280.

Bruns J Jr, Hauser WA. The epidemiology of traumatic brain injury. A review. Epilepsia 2003; 44: 2-10.

Buchanan J, Colquhoun A, Friedlander L, Evans S, Whitley B, Thompson M. Maxillofacial fractures at Waikato Hospital, New Zealand: 1989 to 2000. N Z Med J 2005; 118: U1529.

Buitrago-Téllez CH, 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 2002; 33: 651-668.

Bullock MR, Chesnut R, Ghajar J, Gordon D, Harti R, Newell DW, Servadel F, Walters BC, Willinberger J. Surgical management of depressed cranial fractures. Neurosurgery 2006; 58: 56-60.

Bulut M, Koksal O, Korkmaz A, Ozguc H. Childhood falls: characteristics, outcome and comparison of the Injury Severity Score and New Injury Severity Score. Emerg Med J 2006; 23: 540-545.

Burstein F, Cohen S, Hudgins R, Boydston W. Frontal basilar trauma: classification and treatment. Plast Reconstr Surg 1997; 99: 1314-1323.

Calderoni DR, De Campos Guidi M, Kharmandayan P, Nunes PHF. Seven-year institutional experience of the surgical treatment of orbito-zygomatic fractures. J Craniomaxillofac Surg 2011; 39: 593-599.

Chapman VM, Fento LZ, Gao D, Strain JD. Facial fractures in children: unique patterns of injury observed by computer tomography. J Comput Assist Tomogr 2009; 33: 70-72.

Centers for Disease Control and Prevention: Leading causes of death. Available at: http://www.cdc.gov/nchs/fastats/lcod.htm. Accessed January 2, 2011.

Chan J, Putnam MA, Feustel PJ, et al: The age dependent relationship between facial fractures and skull fractures. Int J Pediatr Otorhinolaryngol 2004; 68: 877-881.

Cheema SA, Amin F. Incidence and causes of maxillofacial skeletal injuries at the Mayo Hospital in Lahore, Pakistan. Br J Oral Maxillofac Surg 2006; 44: 232-234.

Chen YH, Lin SZ, Chiang YH, Ju DT, Liu MY, Chen GJ. Supraorbital Keyhole Surgery for Optic Nerve Decompression and Dura Repair. J Neurotrauma 2004; 21: 976-981.

Chen KT, Chen CT, Mardini S, Tsay PK, Chen YR. Frontal sinus fractures: a treatment algorithm and assessment of outcomes based on 78 clinical cases. Plast Reconstr Surg 2006; 118: 457-468.

Choi D, Spann R. Traumatic cerebrospinal fluid leakage, risk factors and use of prophylactic antibiotics. Br J Neurosurg 1996; 10: 571-575.

Chong VFH, Khoo JBK, Fan Y-F. Imaging of the nasopharynx and skull base. Neuroimag Clin N Am 2004; 14: 695-719.

Chrcanovic BR, Souza LN, Freire-Maia B, Abreu MH. Facial fractures in the elderly: a retrospective study in a hospital in Belo Horizonte, Brazil. J Trauma 2010; 69: 73-78.

Chuang SK, Dodson TB. Evaluation and management of frontal sinus injuries. In: Fonseca RJ, Walker RV, Betts N, Powers MP, Barber HD (eds.) Oral and Maxillofacial Trauma. Vol 2, ed. 3. Philadelphia, Saunders; 2004. p. 721-735.

Clauser L, Dallera V, Sarti E, Tieghi R. Frontobasilar fractures in children. Childs Nerv Syst 2004; 20: 168-175.

Cortes MI, Marcenes W, Sheiham A. Impact of traumatic injuries to the permanent teeth on the oral health-related quality of life in 12-14-year old children. Community Dent Oral Epidemiol 2002; 30: 193-198.

Cunningham Jr., Larry L.; Haug, Richard H, Maxillofacial Trauma: Management of Frontal Sinus and Naso-orbitoethmoid Complex Fractures. In: Peterson's Principles of Oral & Maxillofacial Surgery Vol. 1. Hamilton, London, BC Decker Inc; 2004. p. 491-508.

Dandy WD. Pneumocephalus (intracranial pneumocele or aerocele). Arch Surg 1926; 12: 949-982.

Da Silva AC, Passeri LA, Mazzonetto R, De Moraes M, Moreira RW. Incidence of dental trauma associated with facial trauma in Brazil: a 1-year evaluation. Dent Traumatol 2004; 20: 6-11.

Daudia A, Biswas D, Jones NS. Risk of meningitis with cerebrospinal fluid rhinorrhea. Ann Otol Rhinol Laryngol 2007; 116: 902-905.

Deb S, Lyons I, Koutzoukis C. Neuropsychiatric sequelae one year after a minor head injury. J Neurol Neurosurg Psychiatry 1998; 65: 899-902.

De Matos FP, Arnez MFM, Sverzut CE, Trivellato AE. A retrospective study of mandibular fracture in a 40-month period. Int J Oral Maxillofac Surg 2010; 39: 10-15.

De Melo WM, Colete JZ, Mariano RC, Shinohara EH, Souza FA, Garcia IR jr. Anterior cranial flap for frontal sinus duct obliteration: is it a valuable source? J Craniofac Surg 2013; 24: 147-149.

Derogatis LR, Lipman RS, Covi L. SCL-90: An out-patient psychiatric rating scale-preliminary report. Psychopharmacol Bull 1973; 9: 13-28.

Dhandapani S, Manju D, Sharma B, Mahapatra A. Prognostic significance of age in traumatic brain injury. J Neurosci Rural Pract 2012; 3: 131-135.

Diaz JA, Bustos L, Brandt AC, Fernandez BE. Dental injuries among children and adosleccents aged 1-15 years attending to public hospital in Temuco, Chile. Dental Traumatol 2010; 26: 254-261.

Donat TL, Endress C, Mathog RH. Facial fracture classification according to skeletal support mechanisms. Arch Otolaryngol Head Neck Surg 1998; 124: 1306-1314.

Donath A, Sindwani R. Frontal sinus cranialization using the pericranial flap: an added layer of protection. Laryngoscope 2006; 116: 1585-1588.

Echo A, Troy JS, Hollier LH Jr. Frontal sinus fractures. Semin Plast Surg 2010; 24: 375-382.

Eggensperger N, Smolka K, Scheidegger B, Zimmermann H, Iizuka T. A 3-year survey of assault-related maxillofacial fractures in central Switzerland. J Craniomaxillofacial Surg 2007; 35: 161-167.

Eggensperger Wymann NH, Hölzle A, Zachariou Z, Iizuka T. Pediatric craniofacial trauma. J Oral Maxillofac Surg 2008; 66: 58-64.

Eilert-Petersson E, Andersson L, Sorensen S. Oral injuries in relation to non.dental oral injuries. Swedish Dental Journal 1997; 21: 55-68.

Elbarbary AS, Ali A. Medial canthopexy of old unrepaired naso-orbito-ethmoidal (noe) traumatic telecanthus. J Craniomaxillofac Surg 2014; 42: 106-112.

Eljamel MS, Foy PM. Acute traumatic CSF fistulae: the risk of intracranial infection. Br J Neurosurg 1990; 4: 381-385.

Ellis E, Moos KF, El-Attar A. Ten years of mandibular fractures: an analysis of 2137 cases. Oral Surg Oral Med Oral Pathol 1985; 59: 120-129.

Eppley BL. Use of resorbable plates and screws in pediatric facial fractures. J Oral Maxillofac Surg 2005; 63: 385-391.

Escher F. Clinic, classification and treatment of the frontobasal fractures. In: Hamberger C-A and Wersäll J (eds.) Disorders of the skull base region. Stockholm, Almqvist and Wiksell; 1969. p. 343-352.

Escher F. Les fractures fronto-basales. Rev Otoneuroophtalmol 1969; 41: 412-413.

Fain J, Chabannes J, Peri G, Jourde J. [Frontobasal injuries and csf fistulas. Attempt at an anatomoclinical classification. Therapeutic incidence].[Article in French]. Neurochirurgie 1975; 21: 493-506.

Ferreira PC, Amarante JM, Silva PN, Rodrigues JM, Choupina MP, Silva AC, Barbosa RF, Cardoso MA, Reis JC. Retrospective study of 1251 maxillofacial fractures in children and adolescents. Plast Reconstr Surg 2005; 115:1500-1508.

Fink P, Jensen J, Borgquist I, Brevik JI, Dalgard OS, Sandager I, Engberg M, Hansson L, Holm M, Joukamaa M et al. Psychiatric morbidity in primary public health care: a Nordic multicentre investigation. Part I: method and prevalence of psychiatric morbidity. Acta Psychiatr Scand 1995; 92: 409-418.

Fishman G, Fliss DM, Benjamin S, Margali N, Derowe A, Constantini S et al. Multidisciplinary surgical approach for cerebrospinal fluid leak in children with complex head trauma. Childs Nerv Syst 2009; 25: 915-923.

Fliss D, Zucker G, Cohen A, Amir A, Sagi A, Rosenberg L, Leiberman A, Gatot A, Reichenthal E. Early outcome and complications of the extended subcranial approach to the anterior skull base. Laryngoscope 1999; 109:153-160.

Fliss DM, Abergel A, Cavel O, Margalit N, Gil Z. Combined subcranial approaches for excision of complex anterior skull base tumors. Arch Otolaryngol Head Neck Surg 2007; 133: 888-896.

Follmar KE, Debrujin M, Baccarani A, Bruno AD, Mukundan S, Erdmann D, Marcus JR. Concomitant injuries in patients with panfacial fractures. J Trauma 2007; 63: 831-835.

Fraioli RE, Branstetter BF 4th, Deleviannis FW. Facial fractures: beyond Le Fort. Otolaryngol Clin North Am 2008; 41: 51-76.

Friedman JA, Ebersold MJ, Quast LM. Post-traumatic cerebrospinal fluid leakage. World J Surg 2001; 25: 1062-1066.

Gassner R, Bösch R, Tuli T, Emshoff R. Prevalence of dental trauma in 6000 patients with facial injuries. Implications for prevention. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999; 87: 27-33.

Gassner R, Tuli T, Hächl O, Rudisch A, Ulmer H. Cranio-maxillofacial trauma: a 10-year review of 9543 cases with 21 067 injuries. J Craniomaxillofac Surg 2003; 31: 51-61.

Gassner R, Tuli T, Hächl O, Moreira R, Ulmer H. Craniomaxillofacial trauma in children: a review of 3,385 cases with 6,060 injuries in 10 years. J Oral Maxillofac Surg 2004; 62: 399-407.

Gentleman D. Improving outcome after traumatic brain injury-progress and challenges. Brit Med Bullet 1999; 55: 910-926.

Ghigo E, Masel B, Aimaretti G, Leon-Cattion J, Casanueva FF, Dominguez-Morales MR, Elovic E, Perrone K, Stalla G, Thompson C, Urban R. Consensus guidelines on screening for hypopituitarism following traumatic brain injury. Brain Inj 2005; 19: 711-724.

Glass RM, Allan T, Uhlenhut EH, Kimball GP, Borinstein DI. Psychiatric screening in a medical clinic. An evaluation of a self-report inventory. Arch Gen Psychiatry 1978; 35: 1189-1195.

Glendor U, Halling A, Andersson L, Eilert-Petersson E. Incidence of traumatic tooth injuries in children and adolescents in the county of Västmanland, Sweden. Swed Dent J 1996; 20: 15-28.

Glendor U, Halling A, Andersson L, Andreasen JO, Klitz I. Type of treatment and estimation of time spent on dental trauma. A longitudinal and retrospective study. Swed Dent J 1998; 22: 47–60.

Glendor U, Andersson L. Public health aspects of oral diseases and disorders: dental trauma. In: Pine C, Harris R (eds.) Community Oral Health. London, Quintessence Publishing; 2007. p. 203-211, 217-254.

Glendor U. Etiology and risk factors related to traumatic dental injuries-a review of literature. Dent Traumatol 2009; 25:19-31.

Gonty AA, Marciani RD, Adornato DC. Management of frontal sinus fractures: a review of 33 cases. J Oral Maxillofac Surg 1999; 57: 372-379.

Goodrich JT, Tepper O, Staffenberg DA. Craniosynostosis: posterior two-third cranial vault reconstruction using bioresorbable plates and PDS suture lattice in sagittal and lamboid synostosis. Childs Nerv Syst 2012; 28: 1399-1406.

Grabe HM, McKean EL, Eggenberger ER, Trobe JD. Persistent diplopia and superior oblique muscle dysfunction following dissection of the orbital periosteum incranial base surgery. Br J Ophthalmol 2013; 97: 1330-1332.

Greig JR: Antibiotic prophylaxis after CSF leaks lacks evidence base. BMJ 2002; 325: 1037.

Guedes OA, de Alencar AHG, Pecora JD, Estrela C. A retrospective study of traumatic dental injuries in a Brazilian Dental Urgency Service. Braz Dent J 2010; 21: 153-157.

Hadad G, Bassagasteguy L, Carrau R, Mataza JC, Kassam A, Snyderman CH, Mintz A. A novel endoscopic expanded endonasal approaches: Vascularized pedicle nasoseptal flap. Laryngoscope 2006; 116: 1882-1886.

Hahn YS, Chyung C, Barthel MJ, Bailes J, Flannery AM, McLone DG. Head injuries in children under 36 months of age. Demographics and outcome. Childs Nerv Syst 1988; 4: 34-40.

Hardt N, Kuttenberger J. Classification of craniofacial fractures. In: Craniofacial Trauma: Diagnosis and management. Berlin Heidelberg, Springer-Verlag; 2010. p. 31-49.

Hecova H, Tzigkounakis V, Merglova V, Netolicky J. A retrospective study of 889 injured permanent teeth. Dent Traumatol 2010; 26: 466-475.

Heiskanen O, Sipponen P. Prognosis of severe brain injury. Acta Neurol Scand 1970; 46: 343-348.

Heller EM, Jacobs JB, Holliday RA. Evaluation of the frontonasal duct in frontal sinus fractures. Head Neck 1989; 11: 46-50.

Hendryk S, Czecior E, Misiolek M, Namyslowsky G, Mrowka R. Surgical strategies in the removal of malignant tumors and benign lesions of the anterior skull base. Neurosurg Rev 2004; 27: 205-213.

Herbella FA, Mudo M, Delmonti C, Braga FM, Del Grande JC. Raccoon eyes (periorbital hematoma) as a sign of skull base fracture. Injury 2001; 32: 745-747.

Hogg NJ, Stewart TC, Armstrong JE, Girotti MJ. Epidemiology of maxillofacial inuries at trauma hospitals in Ontario, Canada, between 1992 and 1997. J Trauma 2000; 49: 425-432.

Hohlriedel M, Hinterhoelzl J, Ulmer h, Lang C, Hackl W, Kampfl A, benzer A, Schmutzhard E, Gassner R. Traumatic intracranial hemorrhages in facial fracture patients:review of 2195 patients. Intensive Care Med 2003; 29: 1095-1100.

Holan G, Peretz B, Efrat J, Shapira Y. Traumatic injuries to teeth in young individuals with cerebral palsy. Dent Traumato 2005; 21: 65-69.

Horowitz G, Fliss DM, Margalit N, Wesserzug O, Gil Z. Association between cerebrospinal fluid leak and meningitis after skull base surgery. Otolaryngology, Heah Neck Surg 2011; 145: 689-693.

Hough RI, Landsverk JA, Jacobson GF. The use of psychiatric screening scales to detect depression in primary care patients. In: Attkisson CC, Zich JM (eds) Depression in primary care: screening and detection. New York, Routledge; 1990. p. 139.

Husain Q, Patel SK, Soni RS, Patel AA, Liu JK, Eloy JA. Celebrating the golden anniversary of the anterior skull base surgery: reflections on the past 50 years and its historical evolution. Laryngoscope 2013; 123: 64-72.

Hwang K, You SH. Analysis of facial bone fractures: An 11-year study of 2094 patients. Indian J Plast Surg 2010; 43: 43-48.

Iizuka T, Randell T, Güven O, Lindquist C. Maxillofacial fractures related to work accidents. J Craniomaxillofac Surg 1990; 18: 255-259.

Imahara SD, Hopper RA, Wang J, Rivara FP, Klein MB. Patterns and outcomes of pediatric facial fractures in the United States: A survey of the National Trauma Data Bank. J Am Coll Surg 2008; 207: 710-716.

Jagannathan J, Okondwo DO, Dumont AS. Outcome following decompressive craniectomy in children with severe traumatic brain injury: a 10-year single center experience with long term follow up. J Neurosurg 2007; 106: 268-275.

Jagannathan J, Okondwo DO, Dumont AS. Outcome following decompressive craniectomy in children with severe traumatic brain injury: a 10-year single center experience with long-term follow up. J Neurosurg: Pediatrics 2007; 2: 268-275.

Jennett B, Bond M. Assessment of outcome after severe brain damage. Lancet 1975; 1: 480-484.

Jennett B, Snoek J, Bond MR, Brooks N. Disability after severe head injury: observations on the use of the Glasgow Outcome Scale. J Neurol Neurosurg Psychiatry 1981; 44: 285-293.

Jennett B. Epidemiology of head injury. J Neurol Neurosurg Psychiatry 1996; 60: 362-369.

Joelsson P, Tenovuo O, Tuominen R. Aivovammojen aiheuttamat hoitokustannukset ja tuotannonmenetykset. Suomen Lääkärilehti 2011; 66: 2771-2775.

Johnson K, Fischer T, Chapman S, Wilson B. Accidental head injuries in children under 5 years of age. Clin Radiol 2005; 60: 464-468.

Joukamaa M, Lehtinen V, Karslsson H, Rouhe E. SCL-25 and regocnition of mental disorders reported by primary health care physicians. Acta Psychiatr Scand 1994; 89: 320-323.

Kadkhodaie MH. Three-year review of facial fractures at a teaching hospital in Northern Iran. Br J Oral Maxillofac Surg 2006; 44: 229-231.

Katzen JT, Jarrahy R, Eby JB, Mathiasen RA, Margulies DR, Shahinian HK. Craniofacial and skull base trauma. J Trauma 2003; 54: 1026-1034.

Kellman R, Marentette L. The transglabellar/subcranial approach to the anterior skull base. Arch Otolaryngol Head and Neck Surg 2001; 127: 687-690.

Kelly DE, Harrigan WF. A survey of facial fractures: Bellevue Hospital, 1948-1974. J Oral Surg 1975; 33: 146-149.

Kim E, Lauterbach EC, Reeve A, Arciniegas DB, Coburn KL, Mendez MF, Rummans TA, Coffey EC; ANPA Committee on Research. Neuropsychiatric complications of traumatic brain injury: a critical review of the literature (a report by the ANPA Committee on Research). J Neuropsychiatry Clin Neurosci 2007; 19: 106-127.

Kim TG, Chung KJ, Kim YH, Lim JH, Lee JH. Medial Canthopexy Using Y-V Epicanthoplasty Incision in the Correction of Telecanthus. Ann Plast Surg 2014; 72: 164-168.

Kinnunen I, Aitasalo K. A review of 59 consecutive patients with lesions of the anterior cranial base operated on using the subcranial approach. J Cranio-Maxillofacial Surg 2006; 34: 405-411.

Kirtane MV, Gautham K, Upadhyaya SR. Endoscopic CSF rhinorrhea closure: our experience in 267 cases. Otolaryngol Head Neck Surg 2005; 132: 208-212.

Koento T. Current advances in sinus preservation for the management of frontal sinus fractures. Curr Opin Otolaryngol Head Neck Surg 2012; 20: 274-279.

Komatsu M, Komatsu F, Cavallo LM, Solari D, Stagno V, Inoue T, Cappabianca P. Purely endoscopic repair of traumatic cerebrospinal fluid rhinorrhea from the anterior skull base. Neurol Med Chir (Tokyo) 2011; 51: 222-225.

Kontio R, Suuronen R, Ponkkonen H, Lindqvist C, Laine P. Have the causes of maxillofacial fractures changed over the last 16 years in Finland? An epidemiological study of 725 fractures. Dent Traumatol 2005; 21: 14-19.

Koudstaal MJ, Van der Wal KGH, Bijvoet HWC, Vincent AJPE, Poublon RMI. Post-trauma mucocele formation in the frontal sinus: a rationale of follow-up. Int J Oral Maxillofac Surg 2004; 33: 751-754.

Koskinen S, Alaranta H. Traumatic brain injury in Finland 1991-2005: A nationwide register study of hospitalized and fatal TBI. Brain Inj 2008; 22: 205-214.

Kraft A, Abermann E, Stigler R, Zsifkovits C, Pedross F, Kloss F, Gassner R. Craniomaxillofacial trauma: synopsis of 14 654 cases with 35 129 injuries in 15 years. Craniomaxillofac Trauma Reconstr 2012; 5: 41-50.

Kubal WS. Updated imaging of traumatic brain injury. Radiol Clin N Am 2012; 50:15-41.

Kumar R, Mahapatra AK. The changing epidemiology of pediatric head injury and its impact on the daily clinical practice. Childs Nerv Syst 2009; 25: 813-823.

Kurol J, Thilander B, Zachrisson B, Linder-Aronson S. Treatment of dento-alveolar and skeletal anomalies. In: Thilander B, Rönning O (eds.) Introduction to Orthodontics, 2nd ed. Karlshamn, Förlagshuset Gothia AB; 1995. p. 141, 146.

La Fata V, McLean N, Wise SK, DelGaudio JM, Hudgins PA. CSF leaks: Correlation of high-resolution CT and multiplanar reformations with intraoperative endoscopic findings. Am J Neuroradiol 2008; 29: 536-541.

Lallier M, Bouchard S, St-Vil D, et al: Falls from heights among children: A retrospective review. J Pediatr Surg 1999; 34: 1060-1063.

Lauridsen E, Hermann NV, Gerds TA, Kreiborg S, Andreasen JO. Pattern of traumatic dental injuries in the permanent dentition among children, adolescents, and adults. Dent Traumatol 2012; 28: 358-363.

Lee K. Global trends in maxillofacial fractures. Craniomaxillofac Trauma Reconstr 2012; 5: 213-222.

Lee KH. Interpersonal violence and facial fractures. J Oral Maxillofac Surg 2009; 67:1878-1883.

Lee JH, Cho BK, Park WJ. A 4-year retrospective study of facial fractures on Jeju, Korea. J Craniomaxillofac Surg 2010; 38: 192-196.

Lee S-Y, kim SS, Kim C-H, Park S-W, Park JH, Yeo M. Prediction of outcome after traumatic brain injury using clinical and neuroimaging variables. J Clin Neurol 2012; 8: 224-229.

Lieger O, Zix J, Kruse A, Iizuka T. Dental injuries in association with facial fractures. J Oral Maxillofac Surg 2009; 67: 1680-1684.

Linnau KF, Stanley RB, Hallam DK, Gross JA, Mann FA. Imaging of high-energy midfacial trauma: what the surgeon needs to know. Eur J Radiol 2003; 48: 17-32.

Li WZ, Zhang MC, Li SP, Zhang LT, Huang Y. Application of computer-aided three-dimensional skull model with rapid prototyping technique in repair of zygomatico-orbito-maxillary complex fracture. Int J Med Robot 2009; 5: 158-163.

Liu P, Wu S, Li Z, Wang B. Surgical strategy for cerebrospinal fluid rhinorrhea repair. Neurosurgery 2010; 66: 281-285, discussion 285-286.

Liu-Shindo M, Hawkins DB. Basilar skull fractures in children. Int J Ped Otorhinolaryngol 1989; 17: 109-117.

Lloyd KM, DelGaudio JM, Hudgins PA. Imaging of skull base cerebrospinal fluid leaks in adults. Radiology 2008; 248: 725-736.

Luerssen TG, Klauber MR, Marshall LF. Outcome from head injury related to patient's age. A longitudinal prospective study of adult and pediatric head injury. J Neurosurg 1988; 68: 409-416.

Madhusudan G, Sharma RK, Khandelwal N, Tewari MK. Nomenclature of frontobasal trauma: a new clinicoradiographic classification. Plast Reconst Surg 2004; 117: 2382-2388.

Malecki J. New trends in frontal sinus surgery. Acta Otolaryngol 1959; 50: 137-140.

Manson PN, Stanwix MG, Yaremchuk MJ, Nam AJ, Hui-Chou H, Rodriquez ED. Frontobasal fractures: Anatomical classification and clinical significance. Plast Reconstr Surg 2009; 124: 2096-2106.

Marcennes W, Murray S. Social deprivation and traumatic dental injuries among 12-year-old schoolchildren in Newham, London. Dent Traumatol 2001; 17: 17-21.

Marshall LF, Maas AI, Marshall SB, Bricolo A, Fearnside M, Iannotti F, Klauber MR, Lagarrigue J, Lobato R, Persson L, Pickard JD, Piek J, Servadei F, Wellis GN, Morris GF, Means ED, Musch B. A multicenter trial on the efficacy of using trilazad mesylate in cases of head injury. J Neurosurg 1998; 89: 519-525.

Masters SJ, McClean PM, Arcarese JS, Brown RF, Campbell JA, Freed HA, Hess GH, Hoff JT, Kobrine A, Koziol DF, Marasco JA, Merten DF, Metcalf H, Morrison JL, Rachlin JA, Shaver JW, Thornbury JR. Skull x-ray examinations after head trauma. Recommendations by a multidisciplinary panel and validation study. N Engl J Med 1987; 316: 84-91.

McCoy AM, Como JJ, Greene G, Laskey SL, Claridge JA. A novel prospective approach to evaluate trauma recidivism: the concept of the past trauma history. J Trauma Acute Care Surg 2013; 75: 116-121.

McGraw BL, Cole RR: Pediatric maxillofacial trauma. Age-related variations in injury. Arch Otolaryngol Head Neck Surg 1990; 116: 41-45.

McGuirt WF Jr, Stool SE. Temporal bone fractures in children: A review with emphasis of long-term sequelae. Clin Pediatr 1992; 31: 12-18.

McMullin BT, Rhee JS, Pintar FA, Szabo A, Yoganandan N. Facial fractures in motor vehicle collisions. Arch Facial Plast Surg 2009; 11: 165-170.

Mealey J. Pediatric Head Injuries. Thomas, Springfield; 1968. p. 88-136.

Meco C, Oberascher G. Comprehensive algorithm for skull base dural lesion and cerebrospinal fluid fistula diagnosis. Laryngoscope 2004; 114: 991-999.

Mendizapal GR, Moreno, Flores CC. Cerebrospinal fluid fistula: frequency in head injuries. Rev Laryngol Otol Rhinol 1992; 113: 423-425.

Metzger MC, Bittermann G, Dannenberg L, Schmelzeisen R, Gellrich NC, Hohlweg-Majert B, Scheifele C. Design and development of a virtual anatomic atlas of the human skull for automatic segmentation in computer-assisted surgery, preoperative planning and navigation. Int J Comput Assist Radiol Surg. 2013; 8: 691-702.

Mithani SK, St-Hilaire H, Brooke BS, Smith IM, Bluebond-Langner R, Rodriguez ED. Predictable patterns of intracranial and cervical spine injury in craniomaxillofacial trauma: analysis of 4786 patients. Plast Reconstr Surg 2009; 123: 1293-1301.

Moe KS, Kim LJ, Bergeron CM. Transorbital endoscopic repair of cerebrospinal fluid leaks. Laryngoscope 2011; 121: 13-30.

Motamedi MHK. An assessment of maxillofacial fractures: a 5-year study of 237 patients. J Oral Maxillofac surg 2003; 61: 61-64.

Mourouzis C, Evans BT, Shenouda E. Late presentation of a mucocele of the frontal sinus: 50 years postinjury. J Oral Maxillofac Surg 2008; 66: 1510-1513.

MRC CRASH Trial Collaborators, Perel P, Arango M, Clayton T, Edwards P, Komolafe E, Poccock S, Roberts I, Shakur H, Steyerberg E, Yulthakasemsunt S. Predicting outcome after traumatic brain injury: a practical prognostic models based on large cohort of international patients. BMJ 2008; 336: 425-429.

Müller ME, Nazarian S, Koch P, Schatzker J. The comprehensive classification of the fractures of long bones. Berlin, Springer; 1990. p. 1-36.

Munk-Jorgensen P, Fink P, Brevik JI, Dalgard OS, Engberg M, Hansson L, Holm M, Joukamaa M, Karslsson H, Lehtinen V, Nettelbladt P, Stefansson C, Sorensen L, Jensen J, Borgquist L, Sandager I, Nordström G. Psychiatric morbidity in primary public health care: a multicenter investigation. Part II: Hidden morbidity and choice of treatment. Acta Psychiatr Scand 1997; 95: 6-12.

Mura P, Kintz P, Ludes B, Gaulier JM, Marquet P, Martin-Dupont S, Vincent F, Kaddour A, Goullé JP, Nouveau J, Moulsma M, Tilhet-Coartet S, Pourrat O. Comparison of the prevalence of alcohol, cannabis and other drugs between 900 injured drivers and 900 control subjects: results of a French collaborative study. Forensic Sci Int 2003; 133: 79-85.

Nahum AM. The biomechanics of facial bone fracture. Laryngoscope 1975; 85: 140-156.

Navabazam A, Farahani SS. Prevalence of traumatic injuries to maxillary permanent teeth in 9- to 14-year-old school children in Yazd, Iran. Dent Traumatol 2010; 26: 154-157.

Naveen Shankar A, Naveen Shankar V, Hegde N, Sharma, Prasad R. The pattern of maxillofacial fractures- a multicenter retrospective study. J Craniomaxillofac Surg 2012; 40: 675-679.

Nelson EL, Melton LJ 3rd, Annegers JF, Laws ER, Offord KP. Incidence of skull fractures in Olmsted County, Minnesota. Neurosurgery 1984; 15: 318-324.

Novelline RA. Squire's fundamentals of radiology. 6th ed. Harvard; 2004. p. 536-540.

Oberascher G, Arrer E. Efficiency of various methods of identifying cerebrospinal fluid in oto- and rhinorrhea. ORL J Otorhinolaryng Relat Spec 1986; 48: 320-325.

Oberascher G. A modern consept of cerebrospinal fluid diagnosis in otorrhea and rhinorrhea. Rhinology 1988; 26: 89-103.

Oikarinen K, Kassila O. Causes and types of traumatic tooth injuries treated in a public dental health clinic. Endod Dent Traumatol 1987; 3: 172–177.

Oikarinen K, Schutz P, Thalib L, Sandor GK, Clokie C, Meisami T, Safar S, Moilanen M, Belal M. Differences in the etiology of mandibular fractures in Kuwait, Canada and Finland. Dent Traumatol 2004; 20: 241-245.

Ort S, Beus K, Isaacson J. Pediatric temporal bone fractures in a rural population. Otolaryngol Head Neck Surg 2004; 131: 433-437.

Overgaard J, Hvid-Hansen O, Land AM, Pedersen KK, Christensen S, Haase J, Hein O, Tweed WA. Prognosis after head injury based on early clinical examination. Lancet 1973; 2: 631-635.

Pappachan B, Alexander M. Correlating facial fracture and cranial injuries. J Oral Maxillofac Surg 2006; 64: 1023-1029.

Parmar H, Gujar S, Shah G, Mukherjo SK. Imaging of the anterior skull base. Neuroimag Clin N Am 2009; 19: 427-439.

Patrocinio LG, Patricinio JA, Borba BH, Bonatti Bde S, Pinto LF, Vieira JV, Costa JM. Mandibular fracture: analysis of 293 patients treated in the hospital of clinics, federal university of Uberlandia. Braz J Otorhinolaryngol 2005; 71: 560-565.

Peltola MJ, Aitasalo KM, Aho AJ, Tirri T, Suonpää JT. Long-term microscopic and tissue analytical findings for 2 frontal sinus obliteration materials._J Oral Maxillofac Surg 2008; 66: 1699-1707.

Petti S, Tarsitani G. Traumatic injuries to anterior teeth in Italian schoolchildren: prevalence and risk factors. Endod Dent Traumatol 1996; 12: 294-297.

Petti S, Cairella G, Tarsitani G. Childhood obesity: a risk factor for traumatic injuries to anterior teeth. Endod Dent Traumatol 1997; 13: 285–288.

Philips BJ, Meguer JX, Redman J, Baker EH. Factors determining the appearance of glucose in upper and lower respiratory tract secretions. Intensive Care Med 2003; 29: 2204-2210.

Piccirilli M, Anichini G, Cassoni A, Ramieri V, Valentini V, Santoro A. Anterior cranial fossa traumas: clinical value, surgical indications, and results-a retrospective study on a series of 223 patients. J Neurosurg B Skull Base 2012; 73: 265-272.

Poole GV, Lewis JL, Devidas M, Hauser CJ, Martin RW, Thomae KR. Psychopathologic risk factors for intentional and nonintentional injury. J Trauma 1997; 42: 711-715.

Posnick JC, Wells M, Pron GE: Pediatric facial fractures: Evolving patterns of treatment. J Oral Maxillofac Surg 1993; 51: 836-844.

Poukens J, Haex J, Riediger D. The use of rapid prototyping in the preoperative planning of distraction osteogenesis of the cranio-maxillofacial skeleton. Comput Aided Surg 2003; 8: 146-154.

Probst R, Grever G, Iro H. Basic Otorinolaryngology: A steb-by-step learning Guide. New York, Georg Thieme Verlag: 2006. p. 44-45.

Prosser DJ, Vender JR, Solares CA. Traumatic cerebrospinal fluid leaks. Otolaryngol Clin N Am 2011; 44: 857-873.

Provenzale JM. Imaging of the traumatic brain injury: a review of recent medical literature. Neuroimag Clin N Am 2009; 19: 427-439.

Rantakallio P. The longitudinal study of the Northern Finland Birth Cohort of 1966. Paediatr Perinat Epidemiol 1986; 2: 59-88.

Rantakallio P, von Wendt L. Mental retardation and subnormality in a birth cohort of 12 000 children in northern Finland. Am J Ment defic 1986; 90: 380-387.

Rashid A, Eyeson J, Haider D, Van Gijn D, Fan K. Incidence and patterns of mandibular fractures during 5-year period in a London teaching hospital. Br J Oral Maxillofac Surg 2013; 51:794-798.

Raveh J, Vuillemin T. The surgical one-stage management of combined cranio-maxillofacial and frontobasal fractures, advantages of the subcranial approach in 374 cases. J Craniomaxillofac surg 1988; 16: 160-172.

Raveh J, Vuillem T, Sutter F. Subcranial management of 395 combined frontobasal-midface fractures. Arch Otolaryngol Head and Neck Surg 1988; 114: 1114-1122.

Raveh J, Vuillem T. Advantages of an additional subcranial approach in the correction of craniofacial deformities. J Craniomaxillofac Surg 1988; 16: 350-358.

Raveh J, Laedrach K, Vuillemin T, Zingg M. Management of combined frontonaso-orbital/skull base fractures and telecanthus in 355 cases. Arch Otolaryngol Head Neck Surg 1992; 118: 605-614.

Raveh J, Turk JB, Laedrach K, Seiler R, Godoy N, Chen J, Paladina J, Virag M, Leibinger K. Extended anterior subcranial approach for skull base tumours: long term results. J Neurosurg 1995; 82:1002-1010.

Raveh J, Laedrach K, Iizuka T, Leibinger F. Subcranial extended anterior approach for skull base tumors: surgical procedure and reconstruction. In: Donald PJ (ed.) Surgery of Skull Base. Philadelphia, Lippincott-Raven; 1998. p. 239-261.

Ravindran V, Ravindran Nair KS. Metaanalysis of maxillofacial trauma in the northern districts of Kerala: One year prospective study. J Maxillofac Oral Surg 2011; 10: 321-327.

Rickels K, Lipman RS, Garcia C-R, Fisher E. Evaluating clinical improvement in anxious outpatients. A comparison of normal and treated neurotic patients. Am J Psychiatry 1972; 128: 1005-1009.

Rivara FP. Pediatric injury control in 1999: Where do we go from here? Pediatrics 1999; 103: 883-888.

Roccia F, Bianchi F, Zavattero E, Tanteri G, Ramieri G. Characteristics of maxillofacial trauma in females: a retrospective analysis of 367 patients. J Craniomaxillofac Surg 2010; 38: 314-319.

Rocchi G, Caroli E, Belli E, Salvati M, Cimatti M, Delfini R. Severe craniofacial fractures with frontobasal involvement and cerebrospinal fluid fistula: indications for surgical repair. Surg Neurol 2005; 63: 559-563, discussion 563-564.

Roehm CE, Brown SM. Unilateral endoscopic approach for repair of frontal sinus cerebrospinal fluid leak. Skull Base 2011; 21: 139-145.

Rontal ML. State of the art in craniomaxillofacial trauma: frontal sinus. Curr Opin Otolaryngol Head Neck 2008; 16: 381-386.

Roth J, Hingst V, Lenz JH. Blindness following severe midfacial trauma-case report and review. J Craniomaxillofac Surg 2012; 40: 608-613.

Sabuncuoglu O, Taser H, Berkem M. Relationship between traumatic dental injuries and attention-deficit hyperactivity disorder in children and adoslescent: proposal of an explanatory model. Dent Traumatol 2005; 21: 249-253.

Sadhwani BS, Anchlia S. Conventional 2.0 mm miniplates versus 3-D plates in mandibular fractures. Ann Maxillofac Surg 2013; 3: 154-159.

Sakas DE, Beale DJ, Ameen AA, Whitwell HL, Whittaker KW, Krebs AJ, Abbasi KH, Dias PS. Compound anterior cranial base fractures: classification using computerized tomography scanning as a basis for selection of patients for dural repair. J Neurosurg 1998; 88: 471-477.

Sakr K, Farag IA, Zeitoun IM. Review of 509 mandibular fractures treated at the university hospital, Alexandria, Egypt. Br J Oral Maxillofac Surg 2006; 44: 107-111.

Salvolini U, Polonara G, Salvolini S. Imaging facial injuries. In Marincek, Borut, Dondelinger, Robert F (eds.) Emergency radiology, imaging and intervention. Berlin Heidelberg, Springer-Verlag; 2007. p. 125-138.

Sandager I, Moum T, Ingebrigtsen G, Dahlgad OS, Sörensen T, Bruusgaard D. Concordance between symptom screening and diagnostic procedure: The Hopkins Symptom Checklist-25 and Composite International Diagnostic Interview I. Soc Psychiatry Psychiatr Epidemiol 1998; 33: 345-354.

Sargent LA. Nasoethmoid orbital fractures: diagnosis and treatment. Plast Reconst Surg 2007; 120: 16S-31S.

Sayfan J, Berlin Y. Previous trauma as a risk factor for recurrent trauma in rural northern Israel. J Trauma 1997; 43: 123-125.

Scarfe WC. Imaging of maxillofacial trauma: evolutions and emerging revolutions. Oral Surg Oral Med Oral Pathol Oral radiol Endod 2005; 100: 575-596.

Schaller B, Hosokawa S, Buttner M, Iizuka T, Thoren H. Occurrence, types and severity of associated injuries of pediatric patients with fractures of frontal skull base. J Craniomaxillofac Surg 2012; 40: 218-221.

Schlosser RJ, Bolger WE. Nasal cerebrospinal fluid leaks: critical review and surgical considerations. Laryngoscope 2004; 114: 255-265.

Scholsem M, Scholtes F, Collignon F, Robe P, Dubuisson A, Kaschten B et al. Surgical management of anterior cranial base fractures with cerebrospinal fluid fistulae: A single-institution experience. Neurosurg 2008; 62: 463-471.

Schuknecht B, Graetz K. Radiologic assessment of maxillofacial, mandibular and skull base trauma. Eur Radiol 2005; 15: 560-568.

Selassie AW, Zaloshnja E, Langlois JA, Miller T, Jones P, Steiner C. Incidence of long-term disability following traumatic brain injury hospitalization, United States, 2003 J Head Trauma Rehabil 2008; 23: 123-131.

Shayegan A, De Maertelaer V, Vanden Abbeele AJ. The prevalence of traumatic dental injuries: a 24-month survey. J Dent Child (Chic) 2007; 74: 194-199.

Shohet MR, Laedrach K, Guzman R, Raveh J. Advances in approaches to the cranial base: minimizing morbidity. Facial Plast Surg 2008; 24: 129-134.

Sigurdsson A. Evidence-base review of prevention of dental injuries. J Endod 2013; 39 (3 Suppl): S88-93.

Simsek S, Simsek A, Abubaker O, Laskin DM. A comparative study of mandibular fractures in the United States and Turkey. Int J Oral Maxillofac Surg 2007; 36: 395-397.

Skaare AB, Jacobsen i. Etiological factors related to dental injuries in Norwegians aged 7-18 years. Dent Traumatol 2003; 19: 304-308.

Smith TL, Han JK, Loehrl TA, Rhee JS. Endoscopic management of the frontal recess in frontal sinus fractures: A shift in the paradigm? Laryngoscope 2002; 112: 784-790.

Snyderman CH, Kassam AB, Carrau R, Mintz A. Endoscopic reconstruction of cranial base defects following endonasal skull base surgery. Skull Base 2007; 17: 73-78.

Sookplung P, Vavilala MS. What is new in pediatric traumatic brain injury? Curr Opin Anaesthesiol 2009; 22: 572-578.

Sonig A, Thakur JD, Chittiboina P, Khan IS, Nanda A. Is posttraumatic cerebrospinal fluid fistula a predictor of posttraumatic meningitis? A US Nationwide Inpatient Sample database study. Neurosurg Focus 2012; 32: E4. Doi: 10.3171/2012.5.FOCUS1269.

Soriano EP, Caldas AF jr, Carvalho MVD, Amorim Filho HA. Prevalence and risk factors related to traumatic dental injuries in Brazilian preschool children. Dent Traumatol 2007; 23: 232-240.

Soriano EP, Caldas Ade F Jr, De Carvalho MV, Caldas KU. Relationship between traumatic dental injuries and obesity in Brazilian schoolchildren. Dent Traumatol 2009; 25: 506-509.

Stanley RB Jr, Becker TS. Injuries of the nasofrontal orifices in frontal sinus fractures. Laryngoscope 1987; 97: 728-731.

Stanley RB Jr, Sires BS, Funk GF, Nerad JA. Management of displaced lateral orbital wall fractures associated with visual and ocular motility disturbances. Plast Reconstr Surg 1998; 102: 972-979.

Stoll W. Operative frontobasaler verletzungen (inklusive orbita) durch den HNO-chirurgen. Eur Arch Otorhinolaryngol Suppl. 1993; 1: 287-307.

Stoll W. The management of the frontobasal injured patient: the point of view of the ENT-surgeon. Euroacademia Multidisciplinaria Neurotraumatologica, Congress Tenerife 1999. http://www.emn.cc/publications/1999_congress4_tenerife/065emn99.pdf

Subhashraj K, Nandakumar N, Ravindran C. Review of maxillofacial injuries in Chennai, India: A study of 2748 cases. Br J Oral Maxillofac Surg 2007; 45: 637-639.

Tan L, Bailey B. Fractures of the frontal sinus. In: Bailey B, Johnson J, Newlands S (eds) Head & Neck Surgery-Otolaryngology. Vol. 1. 4th ed. Philadelphia, Lippincott Williams & Wilkins; 2006. p. 1009-1015.

Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet 1974; 2: 81-84.

Thomale UW, Graetz D, Vajkoczy P, Sarrafzadeh AS. Severe traumatic brain injury in children-a single center experience regarding therapy and long-term outcome. Childs Nerv Syst 2010; 26: 1563-1573.

Thorén H, Iso-Kungas P, Iizuka T, Lindqvist C, Törnwall J. Changing trends in causes and patterns of facial fractures in children. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009; 107: 318-324.

Thorén H, Snäll J, Salo J, Suominen-Taipale L, Kormi E, Lindqvist C, Törnwall J. Occurrence and types of associated injuries in patients with fractures of the facial bones. J Oral Maxillofac Surg 2010; 68: 805-810.

Thorén H, Seto I, Buttner M, Schaller B, Suominen AL, Iizuka T. Patterns of frontobasal and frontosinal fractures in children and teenagers relative to developmental stage of the facial skeleton. Arch Otolaryngol Head Neck Surg 2011; 137: 549-556.

To EW, Yuen EH, Tsang WM, Lai EC, Wong GK, Sun DT, Chan DT, Lam JM, Ahuja A, Poon WS. The use of stereotactic navigation guidance in minimally invasive transnasal nasopharyngectomy: a comparison with the conventional open transfacial approach. Br J Radiol 2002; 75: 345-350.

Todd JE, Dodd T. Children's dental health in the United Kingdom 1983, Office of Population Censuses and Surveys, London; 1985. p. 98–102.

Tung TC, Tseng WS, Chen CT, Lai JP, Chen YR. Acute life-threatning injuries in facial fracture patients: a review of 1025 patients. J Trauma 2000; 49: 420-424.

Van Bakelen NB, Buijs GJ, Jansma J, de Visscher JG, Hoppenreijs TJ, Bergsma JE, Stegenga B, Bos RR. Comparison of biodegradable and titanium fixation systems in maxillofacial surgery: a two-year multi-center randomized controlled trial. J Dent Res 2013; 92: 1100-1105.

Van de Beek D, Drake JM, Tunkel AR. Nosocomial bacterial meningitis. N Engl J Med 2010; 362: 146-154.

Van Hout WM, Van Cann EM, Abbink JH, Koole R. An epidemiological study of maxillofacial fractures requiring surgical treatment at a tertiary trauma centre between 2005 and 2010. Br J Oral Maxillofac Surg 2013; 51: 416-420.

Vetter JD, Topazian RG, Goldberg MH, Smith DG. Facial fractures occuring in a medium-sized metropolitan area: recent trends. Int J Oral Maxillofac Surg 1991; 20: 214-216.

Vyas RM, Dickinson BP, Wasson KL, Roostaeian J, Bradley JP. Pediatric facial fractures: current national incidence, distribution and Health Care Resource use. J Craniofac Surg 2008; 19: 339-349.

Warner N, Eggensperger E. Traumatic optic neuropathy; a review of current literature. Curr Opin Opthalmol 2010; 21: 459-462.

Weber R, Draf W, Kahle G, Kind M. Obliteration of the frontal sinus--state of the art and reflections on new materials. Rhinology 1999; 37: 1-15.

Wei CW, Montanera W, Selchen D, Lian J, Stevens C, De Tilly LN. Blunt cerebrovascular injuries: diagnosis and management outcomes. Can J Neurol Sci 2010; 37: 574-579.

Whatley WS, Allison DW, Chandra RK, Thompson JW, Boop FA. Frontal sinus fractures in children. Laryngoscope 2005; 115: 1741-1745.

Whetsell LA, Patterson CM, Young DH, Schiller WR. Preinjury psychopathology in trauma patients. J Trauma 1989; 29: 1158-1161, discussion 1161-1162.

World Health Organization: Alcohol and interpersonal violence: Policy briefing, World Health Organization. Regional Office for Europe, 2005. p. 1-16.

Wright G, Bell A, Glashan G, Vincent C, Welbury RR. Dentoalveolar trauma in Glasgow: an audit of mechanism and injury. Dent Traumatol 2007; 23: 226-231.

Yilmazlar S, Arslan E, Kocaeli H, Dogan S, Aksoy K, Korfali E, Doygun M. Cerebrospinal fluid leakage complicating skull base fractures: analysis of 81 cases. Neurosurg Rec 2006: 29: 64-71.

Zaben M, El Ghoul W, Belli A. Post traumatic head injury pituitary dysfunction. Disability & Rehabilitation 2013; 35: 522-525.

Zix JA, Schaller B, Lieger O, Saulacic N, Thoren H, Tateyuki I. Incidence, etiology and pattern of mandibular fractures in central Switzerland. Swissmed Wkly 2011; 141: w13207. Doi: 10.4414/smw.2011.13207.

APPENDIX 1

OULUN YLIOPISTO

P O H J O I S - S U O M E N K O H O R T T I 1 9 6 6 : N H Y V I N V O I N T I - J A T E R V E Y S T U T K I M U S O H J E L M A

KYSELYLOMAKKEEN VASTAUSOHJEET

Vastaa rengastamalla sen vaihtoehdon numero, joka sopii kohdallesi ja/tai kirjoita tieto sitä varten varattuun tilaan. Osa kysymyksistä on taulukkomuodossa, merkitse silloin asianomainen tieto taulukkoon. Muista vastata kaikkiin kysymyksiin - merkitse myös kieltävä vastaus näkyviin joko rengastamalla vaihtoehtoa "ei" vastaava numero tai merkitsemällä "0" vastaukselle varattuun tilaan. Älä kirjoita viivakoodien päälle. Älä myöskään kirjoita nimeäsi lomakkeeseen.

Joissakin kysymyksissä on tiettyjen vaihtoehtojen jälkeen merkintä: “Siirry kysymykseen...”, jolloin voit siirtyä suoraan tähän kysymykseen ja jättää väliin jäävän kysymyksen vastaamatta. Tarvittaessa omainen tai lähihoitaja voi avustaa lomakkeen täyttämisessä.

ELÄMÄNTILANNE JA TAUSTATIEDOT

6. Mikä on peruskoulutuksesi?

1 alle 9 vuotta peruskoulua
2 peruskoulu
3 ylioppilastutkinto

7. Mikä on ammattikoulutuksesi?
(merkitse ylin tähän mennessä suoritettu ja jos jokin koulutus on kesken)

1 ei ammattikoulutusta
2 ammattikurssi
3 ammattikoulu
4 opistotasoinen koulutus
5 ammattikorkeakoulu
6 varsinainen korkeakoulututkinto
7 muu koulutus, mikä?____________________
8 koulutus on kesken, mikä?____________________

10. Painosi |__|__|__| kg

Pituutesi |__|__|__| cm

LIIKUNTA JA FYYSINEN SUORITUSKYKY

13. Kuinka <u>usein</u> harrastat vapaa-aikanasi liikuntaa?

	kerran kuu-kaudessa tai harvemmin	2-3 kertaa kuukau-dessa	kerran viikossa	2-3 kertaa viikossa	4-6 kertaa viikossa	päivittäin
Kevyttä liikuntaa (et hengästy tai hikoile)……………………………………	1	2	3	4	5	6
Ripeää liikuntaa (hengästyt ja hikoilet ainakin lievästi)………………………………………………..	1	2	3	4	5	6

14. Kuinka <u>kauan kerralla</u> harrastat liikuntaa?

	en lainkaan	alle 20 minuuttia	20-39 minuuttia	40-59 minuuttia	1-1,5 tuntia	yli 1,5 tuntia
Kevyttä liikuntaa (et hengästy tai hikoile)……………………………………	1	2	3	4	5	6
Ripeää liikuntaa (hengästyt ja hikoilet ainakin lievästi)…………………………	1	2	3	4	5	6

AMMATTI JA TYÖHISTORIA

15. Mikä seuraavista kuvaa parhaiten nykyistä työtilannettasi?
(päätoimesi osalta)
1 vakituisessa kokopäivätyössä
2 määräaikaisessa kokopäivätyössä
3 osa-aikatyössä
4 itsenäisenä ammatinharjoittajana
5 yrittäjänä
6 päätoimisena opiskelijana
7 työttömänä
8 työvoimapoliittisella tuella koulutuksessa tai työllistettynä
9 lomautettuna tai lyhennetyllä työviikolla
10 äitiys-/vanhempainlomalla, hoitovapaalla
11 eläkkeellä
12 muusta syystä työelämän ulkopuolella, miksi?_________________________

16. Mikä seuraavista vaihtoehdoista kuvaa parhaiten työhistoriaasi?
1 olen ollut koko työhistoriani ajan työssä
2 olen ollut pääasiassa pitkissä työsuhteissa ajoittaisen työttömyyden lisäksi
3 olen ollut sekä pitkissä että lyhyehköissä työsuhteissa ajoittaisen työttömyyden lisäksi
4 työsuhteeni ovat olleet pääasiassa lyhyitä, mutta olen kuitenkin ollut enemmän työssä kuin työttömänä
5 olen ollut enemmän työttömänä kuin työssä ja työsuhteet ovat olleet lyhytaikaisia
6 olen saanut lähes kaikki työsuhteeni työvoimapoliittisten tukitoimenpiteiden kautta (tukityöllistäminen, harjoitteluraha, työmarkkinatuki jne.)
7 en ole koskaan ollut ansiotyössä

17. Mikä on nykyinen ammattisi tai toimesi
(merkitse vaikka olisit tilapäisesti poissa työelämästä mm. sairauden tai työttömyyden vuoksi, merkitse ammattinimike tarkasti; esim. ei autonkuljettaja vaan kuorma-autonkuljettaja, ei apumies vaan rakennusapumies jne.)

____

____

21. Jos olet työtön, kuinka kauan nykyinen työttömyytesi on jatkunut yhtäjaksoisesti?
|___|___| vuotta |___|___| kuukautta

22. Kuinka kauan olet ollut työttömänä yhteensä elämäsi aikana?
|___|___| vuotta |___|___| kuukautta

TERVEYDENTILA

30. Seuraavassa on lueteltu ongelmia ja vaivoja, joita useimmilla ihmisillä silloin tällöin on. Rengasta vaihtoehdoista se, joka parhaiten kuvaa kuinka paljon kyseinen ongelma on vaivannut sinua <u>viimeksi kuluneen viikon aikana.</u>

	ei lainkaan	jonkin verran	melko paljon	erittäin paljon
Päänsärky	1	2	3	4
Nukahtamisvaikeudet	1	2	3	4
Tunne, että tulevaisuus on toivoton	1	2	3	4
Jännittyneisyys tai ylirasittuneisuus	1	2	3	4
Yksinäisyyden tunne	1	2	3	4
Tunne, että koko elämä on ollut jatkuvaa ponnistelua	1	2	3	4
Pakokauhun tai ahdistuksen puuskat	1	2	3	4
Niin voimakas levottomuuden tunne, että on ollut vaikea istua paikallaan	1	2	3	4
Arvottomuuden tunne	1	2	3	4
Hermostuneisuus ja levottomuus	1	2	3	4
Huimaus tai pyörtymisen tunne	1	2	3	4
Huolestuneisuus	1	2	3	4
Sukupuolisen mielenkiinnon tai nautinnon puuttuminen	1	2	3	4
Tarmokkuuden puuttuminen tai voimattomuus	1	2	3	4
Ajatukset elämäsi lopettamisesta	1	2	3	4
Vapina	1	2	3	4
Huono ruokahalu	1	2	3	4
Itkuherkkyys	1	2	3	4
Lukittuna tai vangittuna olemisen tunne.	1	2	3	4
Äkillinen levottomuuden tunne ilman varsinaista syytä	1	2	3	4
Itsesyytökset	1	2	3	4
Alakuloisuus	1	2	3	4
Kiinnostuksen puute	1	2	3	4
Tuskaisuus	1	2	3	4
Sydämentykytys	1	2	3	4

TERVEYDENTILA

34. Kuinka monta seuraavan tyyppistä lääkärin hoitoa vaatinutta tapaturmaa sinulle on sattunut?
(merkitse 0, ellei yhtään)

työtapaturmia	|__|__| kpl
liikennetapaturmia	|__|__| kpl
kotitapaturmia	|__|__| kpl
liikuntatapaturmia	|__|__| kpl
muita vapaa-ajan tapaturmia	|__|__| kpl
väkivalta, pahoinpitely	|__|__| kpl

35. Kuinka monta omaa hammasta sinulta puuttuu?

1 ei yhtään hammasta
2 1 - 5 hammasta
3 6 - 10 hammasta
4 yli 10 hammasta, mutta ei kaikki
5 kaikki hampaat puuttuvat

Onko sinulla koskaan ollut mitään seuraavia <u>lääkärin</u> toteamia tai hoitamia oireita, sairauksia tai vammoja?

	ei	kyllä
Muu nivelsairaus..	1	2
Selän kulumavika, muu selkäsairaus........................	1	2
Syöpä...	1	2
Tyrä..	1	2
Anemia (vähäverisyys, matala hemoglobiini)............	1	2
Mielisairaus, psykoosi...	1	2
Masennus, depressio..	1	2
Muu mielenterveysongelma....................................	1	2
Alkoholiongelma..	1	2
Muu päihdeongelma..	1	2
Luunmurtumia, kuinka monta?_________...............	1	2
Oikomishoitoa vaatinut purentavika.........................	1	2
Muu sairaus tai vamma, mikä?__________________	1	2

ELINTAVAT

70. Käytätkö nykyisin edes satunnaisesti mitään alkoholijuomia?
(esim. olutta, siideriä, mietoja viinejä, viiniä tai väkeviä)
1 en ole koskaan käyttänyt, *siirry kysymykseen 79*
2 en, sillä lopetin alkoholinkäytön kokonaan |___|___| vuotta sitten, *siirry kysymykseen 79*
3 kyllä, harvemmin kuin kerran kuukaudessa
4 kyllä, vähintään kerran kuukaudessa

71. Kuinka <u>usein</u> tavallisesti juot olutta (IVA tai III), **siideriä tai long-drink-juomia?**
1 en koskaan
2 kerran vuodessa tai harvemmin
3 pari kertaa vuodessa
4 3-4 kertaa vuodessa
5 kerran parissa kuukaudessa
6 kerran kuukaudessa
7 pari kertaa kuukaudessa
8 kerran viikossa
9 muutaman kerran viikossa
10 päivittäin

72. Kuinka <u>paljon</u> tavallisesti juot olutta (IVA tai III), **siideriä tai long-drink-juomia kerralla?** (1 pullo = 1/3 l)
1 vähemmän kuin yhden pullon
2 1 pullon
3 2 pulloa
4 3 pulloa
5 4 - 5 pulloa
6 6 - 9 pulloa
7 10 - 14 pulloa
8 15 pulloa tai enemmän
9 en juo mainittuja juomia

73. Kuinka usein tavallisesti juot kevytviiniä?
(alkoholipit. n. 5%)
1 en koskaan
2 kerran vuodessa tai harvemmin
3 pari kertaa vuodessa
4 3-4 kertaa vuodessa
5 kerran parissa kuukaudessa
6 kerran kuukaudessa
7 pari kertaa kuukaudessa
8 kerran viikossa
9 muutaman kerran viikossa
10 päivittäin

74. Kuinka paljon tavallisesti juot kevytviiniä (alkohol. pit. 5%) **kerralla?**
1 puoli lasia
2 lasin (=16cl)
3 pari lasia
4 noin puoli isoa pulloa (iso pullo = 3/4l)
5 hieman vähemmän kuin ison pullon
6 noin yhden ison pullon
7 yhdestä kahteen isoa pulloa
8 enemmän kuin kaksi isoa pulloa
9 en juo kevytviiniä

75. Kuinka usein tavallisesti juot viiniä?
(mietoa tai väkevää, myös kotitekoista)
1 en koskaan
2 kerran vuodessa tai harvemmin
3 pari kertaa vuodessa
4 3-4 kertaa vuodessa
5 kerran parissa kuukaudessa
6 kerran kuukaudessa
7 pari kertaa kuukaudessa
8 kerran viikossa
9 muutaman kerran viikossa
10 päivittäin

76. Kuinka paljon tavallisesti juot mietoja, väkeviä tai kotitekoisia viinejä kerralla?
1 puoli lasia
2 lasin (=16cl)
3 pari lasia
4 noin puoli isoa pulloa (iso pullo = 3/4l)
5 hieman vähemmän kuin ison pullon
6 noin yhden ison pullon
7 yhdestä kahteen isoa pulloa
8 enemmän kuin kaksi isoa pulloa
9 en juo viiniä

77. Kuinka usein tavallisesti juot väkeviä alkoholijuomia?
1 en koskaan
2 kerran vuodessa tai harvemmin
3 pari kertaa vuodessa
4 3-4 kertaa vuodessa
5 kerran parissa kuukaudessa
6 kerran kuukaudessa
7 pari kertaa kuukaudessa
8 kerran viikossa
9 muutaman kerran viikossa
10 päivittäin

78. Kuinka paljon tavallisesti juot väkeviä alkoholijuomia kerralla?

1 vähemmän kuin yhden ravintola-annoksen kerralla (alle 4 cl)
2 yhden ravintola-annoksen (noin 4 cl)
3 pari ravintola-annosta
4 3 - 4 ravintola-annosta
5 5 - 6 ravintola-annosta
6 7 - 10 ravintola-annosta
7 noin puolen litran pullon
8 enemmän kuin puolen litran pullon
9 en juo väkeviä alkoholijuomia

APPENDIX 2

OULUN YLIOPISTO

POHJOIS-SUOMEN KOHORTTI 1966:N HYVINVOINTI- JA TERVEYSTUTKIMUSOHJELMA

KYNÄMIKROKYSYMYKSET

17. Onko sinulla koskaan ollut seuraavia kasvojen alueen vammoja?

	ei	kyllä, oma mielipide	kyllä, lääkärin tai hammaslääkärin toteama
Hampaan/hampaiden lohkeaminen.......	1	2	3
Hampaan/hampaiden tapaturmainen siirtyminen...	1	2	3
Hampaan/hampaiden irtoaminen.........	1	2	3
Alaleuan murtuma...............................	1	2	3
Yläleuan murtuma...............................	1	2	3
Muu kasvojen alueen murtuma...........	1	2	3
Leukanivelalueen vamma.....................	1	2	3
Muu kasvovamma...............................	1	2	3

21. Onko sinulla seuraavia hampaistoon ja leukoihin liittyviä poikkeavuuksia?

	ei	kyllä
Yläetuhampaat voimakkaasti eteenpäin kallistuneet........	1	2
Alaleuka on eteenpäin työntynyt yläleukaan verrattuna.....	1	2
Alaleuka on selvästi taaempana yläleukaan verrattuna.....	1	2
Suoraan edestäpäin katsottuna alaleuka on vinossa........	1	2

24. Kuinka usein yleensä harrastat seuraavia liikuntamuotoja?
Valitse se vaihtoehto, joka parhaiten kuvaa keskimääräistä tilannetta edellisen vuoden aikana kunkin lajin harrastamiseen sopivana vuodenaikana.

	en lainkaan	kerran kuukau-dessa tai harvemmin	2-3 kertaa kuukau-dessa	kerran viikossa	2-3 kertaa viikossa	4 kertaa viikossa tai useammin
Kuntoliikunta						
Kävelylenkkeily………………………….. ..	1	2	3	4	5	6
Pyöräily	1	2	3	4	5	6
Hiihto (murtomaa)	1	2	3	4	5	6
Uinti	1	2	3	4	5	6
Juoksulenkkeily	1	2	3	4	5	6
Kuntosaliharjoittelu	1	2	3	4	5	6
Laskettelu	1	2	3	4	5	6
Aerobic	1	2	3	4	5	6
Voimistelu	1	2	3	4	5	6
Sulkapallo, lentopallo, tennis, squash…….	1	2	3	4	5	6
Sähly, jääkiekko, jalkapallo, kaukalopallo, koripallo……..	1	2	3	4	5	6
Golf	1	2	3	4	5	6
Ammunta	1	2	3	4	5	6
Moottoriurheilu (ralli)	1	2	3	4	5	6
Tanssi	1	2	3	4	5	6
Maastoajoneuvolla ajo (moottorikelkka, mönkijä, maastomoottoripyörä)	1	2	3	4	5	6
Muu ruumiillista rasitusta sisältävä toiminta						
Pihatyöt	1	2	3	4	5	6
Vaellus, retkeily..	1	2	3	4	5	6
Metsästys, kalastus	1	2	3	4	5	6
Marjastus	1	2	3	4	5	6

27. Mitä mieltä olet painostasi?
Oletko mielestäsi:

1 paljon liikapainoinen
2 hieman liikapinoinen
3 sopivan painoinen
4 hieman tai paljon alipainoinen