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Fouche, Gerhard

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The epidemiology and management of traumatic facial fractures in children under the age of 15 years recorded in a Johannesburg General hospital over a period of 5 years

GERHARD FOUCHE

STUDENT NUMBER 685351

MSC DENT

SUPERVISOR: DR MZUBANZI MABONGO

CO-SUPERVISOR: DR MAPHEFO THEKISO

A Research Report submitted to the Department of Maxillofacial and Oral Surgery, Faculty of Oral Health Science, University of Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Dentistry (Witwatersrand) performed partly in the Department of Maxillofacial and Oral Surgery

18 May 2017

Declaration

I, **Gerhard Fouche,** declare that this research report is my own, original work. It is being submitted for the Degree of Master of Dentistry in the Department Maxillofacial and Oral Surgery, University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

_____ [Signature of Candidate]

…… day of …… [month], 20…..

Dedication

I dedicate this work to:

The Almighty God, my wife Maryke and our son and in beloved memory of my mother.

Acknowledgments

I would hereby like to thank Dr. M Mabongo for his loyal support, guidance, knowledge, and expertise. I am truly grateful and I appreciate it.

Special thanks to Dr. M Thekiso for your valuable comments, briefing and academic knowledge.

I would also like to thank:

- The CEO / Clinical Director of the CMJAH, Ms. G Bogoshi, for granting me access to the Paediatric Casualty ward and allowing me the usage of patient admission books and patient records;
- The CEO / Head of Wits Oral Health Centre, Prof P Hlongwa for allowing me the use of patient records in the Department of Maxillofacial and Oral Surgery;
- The Clinical Head of Department of Surgery, Dr. TE Luvhengo for granting me access to the Department of Surgery and usage of patient records.

Special thanks to the sisters and staff, working in the wards of Paediatric casualty and Paediatric surgery for allowing me the time to gain information from the admission books.

I want to express gratitude to the friendly and helpful staff of the CMJAH working in the patient records storage division for your assistance during my data collection.

I give special thanks to my wife, parents, family, and friends for their loyal support, compassion and understanding and allowing me the time to do this.

Above all, I am grateful to my Creator. I thank the gracious Lord for His inspiration during desperate times, His guidance and for always being there.

Abstract

Aim: This study aim was to determine the prevalence of traumatic facial fractures in children under the age of 15 years who presented at the Charlotte Maxeke Johannesburg Academic Hospital (Department of Maxillofacial and Oral surgery, Wits Oral Health Centre and Department of General Surgery) over a period of 5 years from 2011 to 2015.

Objective: This study objective was to determine the prevalence of facial bone fractures, the age and gender mostly affected, the place and cause of facial fracture, the type and distribution of facial fractures, the prevalence of associated injuries as well as the management of facial fractures.

Materials and methods: This is a retrospective study based on data retrieved from patient records. Four thousand and forty-four files were used for the analysis of this study. Data collected from existing patient records included: department of admission; date of admission; age; gender; who accompanied the patient to hospital; ethnicity; medical history; number of days between date of injury and date of arrival; place of injury; cause of fracture; site of fracture; type of fracture; teeth affected; associated facial injuries; ophthalmic or globe involvement; associated bodily injuries; specialized consultation; radiographs; management and treatment of injuries.

The results: Cases numbering 171 children under the age of 15 years with facial bone fractures were retrieved from patient records. Majority of the patients were males. Mean age of patients was 6.45 ± 3.47 years. Most common places of injury included the home, school and other places which refer to any other environment, surrounding area or public place in the home or school. Most common causes of paediatric facial fracture injury are pedestrian-vehicle accidents (PVAs), motor vehicle accidents (MVAs) and falls, with a significant association between the cause of fracture and the age of the patients. Two hundred and forty seven facial bone fractures were detected. Most common site of facial fracture was the frontal bone followed by the orbital bone. Fifty six paediatric patients had multiple facial bone fractures. Forty nine children had an associated tooth injury. Of the 435 facial soft tissue injuries (STIs) detected, 91.0% were extra orally. Most common STIs were lacerations, abrasions and soft tissue swellings. Seventy four of the 117 paediatric patients with associated bodily injuries, had multiple bodily injuries. Twelve patients with facial bone fractures showed results of ophthalmic or globe involvement. One hundred and nine (63.7%) patients with facial bone fractures were managed conservatively, whilst management of 58

(34.0%) patients included surgical intervention. Four (2.3%) patient records did not indicate any treatment.

Conclusion: Most facial bone fractures were recorded in children under the age of 10 years and male gender was most affected. Aetiology of facial fractures seems to be more similar in male and female children at a younger age, whereas more variation in aetiology occurs in gender during adolescence. This study suggests that the school is the safest place for children. The seasonal variance in terms of paediatric facial fracture prevalence is most likely related to an increased outdoor activity during the months of summer. Possible reasons that contribute to home and other places as high-risk areas for facial fractures in children could either be lack of parental supervision and responsibility, or the absence of safety measures. More children were involved in PVAs than MVAs. The negligence of drivers, lack of road safety awareness, insufficient pedestrian safety measures or inadequate parental control is potential factors to contribute to the high prevalence of MVAs and PVAs as a major aetiological factor amongst children in these affected communities. From this study, it seems that the mechanism of injury and stage of facial development shows a noticeable influence on the type and site of the bone fracture and that the frequency of aetiological factors changes with age. Management and treatment of paediatric facial fractures should be with a good understanding of the patterns of anatomical growth and stages of skeletal development.

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Abbreviations

MVA	Motor vehicle accident
NOE	Naso-orbito-ethmoidal
IMF	Intermaxillary fixation
MMF	Maxillomandibular fixation
PAN	Panorex
PA	Posterior anterior
CT	Computerized tomography
3D	Three-dimensional
WITS	University of Witwatersrand
UCT	University of Cape Town
CMJAH	Charlotte Maxeke Johannesburg Academic Hospital
TMJ	Temporomandibular joint
PVA	Pedestrian-vehicle accident
FFH	Fall from height
MFOS	Maxillofacial and Oral surgery
ADHD	Attention deficit hyperactivity disorder
STI	Soft tissue injury
ENT	Ear, nose and throat
FAST	Focussed assessment with sonography for trauma
2D	Two-dimensional
ORIF	Open reduction internal fixation
CRMF	Closed reduction maxillary fixation

CHAPTER 1: INTRODUCTION

Severe head and facial injuries (intentional or unintentional) have globally been recognized as some of the leading causes of mortality and morbidity, prolonged hospital admissions and higher injury severity scores in young children. [1 – 7]

In the United States, it has been reported that head trauma remains the most common cause of death due to injury in the paediatric age group. [4 - 6] In conjunction, traumatic dental-alveolar injuries among young children are also being considered as a serious public dental health problem in many countries. [1, 4, 8 - 12]

Orofacial trauma can be regarded as extra-oral or intra-oral injuries resulting from an external force. These intra- and extra-oral injuries include trauma to facial soft tissues and facial bones, including the dental-alveolus, teeth, oral soft tissues, and the tongue. [3, 8, 13]

The impact of facial trauma associated with severe injury often results in a subsequent functional and aesthetic defects in the growing child, [6, 10, 14] and significantly affects the normal social functioning and quality of life of children. [15] The important functions, such as speech, mastication, respiration, and deglutition may adversely be affected. [16]

In conjunction with the specific anatomic features of paediatric patients, the social-economic impact of social-, cultural-, environmental factors, human behaviour and specific oral factors, show great influence in the incidence and cause of orofacial trauma in children. [2, 4, 12, 14, 17 - 24]

The variation in the degree of motor development skills is frequently related to the specific cause or type of injury. [2, 3, 8, 12, 13] Simultaneously in early childhood the development of sensory systems, neural control mechanisms, cognitive ability and avoidance skills are not yet sufficient to sustain injury. [7]

The paediatric patient can be categorized according to various stages of growth and development. [25] (*Neonate*: newborn up to 1 month; *Infant*: two months to two years; *Child*: three to twelve years; *Adolescent*: thirteen to sixteen years)

CHAPTER 2: LITERATURE REVIEW (background)

According to various studies, facial fractures occur less frequently in children than in adults and are more often minimally displaced. [26] Paediatric patients are also more likely than adults to sustain greenstick or incomplete fractures, and fractures that are less likely to have multiple communications. [26, 27] Facial fractures in children often appear to be long and irregular in character with the fracture generally running inferiorly and anteriorly. [26]

The reduced frequency of facial fractures in children, compared to adults, are most possibly due to the following unique anatomic features: [1, 3, 5, 6, 17-19, 21-23, 25-28]

- Under-developed facial skeleton and para-nasal air sinuses;
- Craniofacial disproportion;
- The thick layer of surrounding adipose tissue that covers the more elastic, thin cortical bones of the paediatric facial skeleton;
- un-erupted dentition (presence of tooth buds and developing crypts) of the mandible and maxilla, and the lack of sinus Pneumatisation provides additional strength and stability of the jaws;
- Abundance of cartilage and cancellous bone, low mineralization and underdeveloped cortex, along with the more flexible suture lines of the facial bones and indistinct corticomedullary junction, confer greater intrinsic elasticity and flexibility on the paediatric facial skeleton;
- Increased number of fat pads around the upper and lower jaws.

The striking feature of the newborn skull is the small size of the facial portion in comparison with the cranial part. At birth the ratio of cranial to facial volume is approximately 8:1 which decreases significantly with age. By the age of 5 years, these relative proportions are nearly 4:1 and with the completion of growth the ratio is closer to 2.5:1. Furthermore, the face of the young child is more retruded relative to the protrusive position of the skull. [2, 5, 6, 18, 21-23, 25, 28 - 31]

The “protecting” skull with its larger volume is the unique feature of young children that associate with the lower incidence of midface and mandibular fractures and higher incidence of skull/cranial fracture (including frontal, superior orbital and upper nasal injuries), especially in children under the age of 5 years. [21, 27, 28, 30] The skull absorbs the full force of the initial impact, thus protecting the face.

With age and physiological development, the midface and the mandible becomes more prominent through the increase of facial growth in a forward and downward direction. From this development, the lower incidence of cranial and frontal injuries and higher incidence of facial trauma (specifically bone fracture injuries of the midface, mandible due to its relative prominence and orbital floor injuries due to the aeration of the maxillary sinus) appears with age. [5, 6, 18, 21, 22, 23, 28, 31]

With age, the more involvement in sports and unsupervised physical activity give rise to a peak in fracture incidence during puberty and adolescence. [12, 28] Other peaks of fracture incidence have been observed between the 6 – 7 years of age, associated with the beginning of school attendance and a second peak at 12 – 14 years of age, related to physical activity and participation in various sports. [5, 19, 22, 23]

Seasonal variations are also evident in different countries, with peak frequencies of facial fractures that occur during certain months of increased outdoor activity and that relate to the involvement in specific sports. [1, 2, 18, 19, 20, 28, 31, 32]

The previous publications also show a higher incidence (approximately twice as frequently) of facial fractures in male patients than female patients, in all age groups worldwide. [29] Although the gender differences show to be less significant and aetiologies more similar in both sexes at younger ages, substantial variation in fracture incidence occur between sexes during adolescence, which often attribute to more intensive and frequent involvement in sports, physical activity and dangerous behaviour among boys. [1, 2, 3, 4, 8, 10, 13, 14, 17, 18, 19, 22, 23, 25, 28, 29, 31, 33, 34, 35]

With interest in paediatric patients involved in polytrauma, children have a higher surface-area-to-body volume ratio with lower total blood and stroke volumes than adults and therefore have a higher risk (than adults) for hypotension, hypothermia, and hypoxia. Especially after massive blood loss, due to the pooling of blood in the peripheral vasculature rather than supplying the viscera, which can result in rapid decompensation. [1, 8, 25, 28] Children also have a higher metabolic rate, oxygen demand and cardiac output than adults, which result in a low physiologic reserve during resuscitation. [25, 28] The smaller body mass of children compared to adults indicate a greater force per unit of body area during an episode of trauma. [25] The impact of trauma on children often results in multiple internal organ injuries due to their incomplete calcified skeleton that is close to the internal organs together with the presence of less fat and more connective tissue. [1, 8, 25] Not only do children

frequently swallow air when injured or frightened, which results in gastric dilatation, but also, infants have relative narrow nasal air passages that can easily obstruct. [1, 8]

Thus, there are various anatomic, physiologic and psychological differences between children and adults that significantly influence the consequence and especially the treatment of trauma. [6, 17, 23, 25]

Previous retrospective studies of maxillofacial trauma in children have shown:

- Not only a lower occurrence of facial trauma among children compared to adults comprising only 3.0% – 6.0% of all facial fractures, [1, 27] but also revealed that craniofacial skeletal injuries comprise of less than 10.0% of all facial fractures [21] (some indicate less than 15.0% [28]);
- That less than 1.0% of facial fractures occurred in children under the age of 5 years; [1 - 3, 5, 8, 19, 21, 25, 28, 29, 36]
- That 1.0% - 14.7% of facial fractures occurred in children under 16 years of age; [1 - 3, 5, 8, 19, 22, 23, 25]
- That the rate of incidence in children under 12 years of age ranges from 1.5% – 8.0% of all facial fractures treated in trauma centers. [29, 33, 36]

METHODS OF INJURY

Although the most common aetiology of facial fractures in children varies from one country to another, this study, therefore, aims to compare local methods of injury with other studies globally. Various studies from across the world state that the most frequent causes of facial injuries and fractures in children are: [1-3, 5, 6, 8, 9, 13, 14, 16, 18, 19, 21, 23, 24, 28, 33]

- falls (either from height, slip or trip);
- road traffic crashes or motor vehicle accidents,
- sports-related injuries,
- bicycle,
- social play;
- pedestrians;
- crushes;
- birth;
- violence;

- assaults;
- child abuse;
- burns

Motor vehicle accidents

Motor vehicle accidents (MVAs) seem to be one of the major causes of unintentional maxillofacial and head injuries in the paediatric population. [4-6, 21-25, 27, 28, 37] The prevalence of these injuries ranges from 34.2% - 57.8% which increases with age (13 – 19 years). [4, 8] A 10-year retrospective study in 2002 from Portugal has reported a 53.3% incidence, which mostly affected children 16 – 18 years of age. [22] A global childhood unintentional injury survey of four cities reported MVAs as the major cause of morbidity in children of which over 70.0% were males above 5 years of age and that pedestrians accounted for most children suffering road traffic injuries. [37]

Falls

Falls (together with slips and trips), regarded as a low-velocity force are frequently the initiating event in paediatric trauma, with the major cranial or facial damage typically caused by a hard or acutely angled object or surface at impact. [2, 7] A child's head with its large mass and volume often becomes the major point of contact when the body falls, which results in the predominance of craniofacial trauma often associated with mild to severe brain injury. [7, 27] Falls are also regarded as one of the main causes of traumatic dental injuries among preschool children. [2, 3, 8, 13, 14, 16, 18, 24, 28, 34, 35]

A study from the Cheng Kung University Hospital in Taiwan done in 2002, reported a bimodal incidence, with peaks in children under 1 year of age and between 5 - 8 years of age. Eighty-three percent of bimodal incidence occurred in children under the age of 6 years, which confirmed a decrease incidence with the level of development. They also reported most of the craniofacial injury sites to the anterior of the head in a T-shape distribution, which involves the forehead, nose, lip, and chin. [2, 7]

A Nigerian study done in 2004 reported falls at a 24.3% incidence rate, which mostly occurred in children under 5 years of age. [23] Falls have been recorded as the most common cause of injury at 44.0% in a study from New Zealand done in 2000, which also showed a predominance in children under the age of 5 years. [13] Two studies were done in Brussels,

one at the Royal children's hospital, Belgium (2005) and the other in Brisbane (2002) also indicated falls as the predominant cause of injury in boys and girls, associated with significant trauma to teeth and associated structures. [10, 35] From a study done in 2007 in Ankara, Turkey, falling while walking or running were reported as the most common aetiology for oral and traumatic dental injuries frequently among children 6 and 8 - 10 years of age. [32]

Sports-related injuries

Sports-related injuries in children also contribute to a major part of facial trauma in children. [24] However, various rates of incidence have been reported from different countries. An incidence rate of 31.8% has been reported from a study in Austria in 2004 [1] compared to the 0.2% incidence from a study in Chile in 2009. [2] Four independent studies conducted in India have reported different rates of incidence regarding sports-related injuries in children. The incidence rates of sports-related injuries from these Indian studies resulted from 13.5% - 42.0%. [3, 8, 18, 15] The type and incidence of facial injuries in children often relate to the intensity and velocity of sports being played. [15, 24] As motor skills improve between the ages of 10 - 14 years, sporting injuries become more prevalent. [28] Age, gender, anatomic risk factors (over jet, incompetent lips, mouth breathing habit, malocclusion, subjects with fixed orthodontic treatment), type of sport, and seasons when the sport is often played is associated with sport-related facial injuries in children and adolescents. [24]

Child Abuse

Child abuse is not an uncommon cause of facial injury. [23] Many cases of child abuse involve trauma to the mouth, face, and head. [38] Repeated injuries, multiple injury sites and questionable circumstances surrounding the injury should raise suspicion of possible abuse. [28] The various studies have shown that as many as 50.0% – 75.0% of cases of child abuse involve trauma to the mouth, face, head, and neck (which mostly include soft tissue lacerations, mandibular and maxillary injuries, and coronal fractures of the maxillary incisors). [25,38] From a study done by Cavalcanti in Brazil, 56.3% of the abused children between 0 – 17 years of age had facial injuries, the prevalence of the abused children were higher among male victims and it showed a higher incidence with age especially in those 11 – 15 years of age and adolescents. [38] This study has also shown a significant association between a number of injuries and gender and of the number of existing injuries and the

presence of oral injuries. [38] Whilst other studies reported a higher frequency of child abuse in girls and children under 10 years of age. [38]

Violence

Although much research focuses on unintentional injury in the United States, there is a growing interest in the injury attributable to violence. [9] The incidence of assaults and interpersonal violence vary from different countries, is an unusual cause of facial fracture in the Paediatric population and is more commonly seen in older age groups. [9, 23, 28] Different rates of incidence regarding violence/assault as a major cause of facial fractures in children have been reported from various previous studies which included the following results: an incidence rate of 48.0% from a study done in South Africa in 1992 [33], 24.3% from a study in Indian children in 2012 [18], 38.0% from a study in Korea in 2012 [19], 22.6% from a study in Brazil in 2005 [39] and 59.0% from a study at 3 trauma centers in Los Angeles in 2008. [9]
Violence has a disproportionate impact on vulnerable youth and the rate of morbidity and mortality in children. [9] Firearm injuries, stab wounds and blunt trauma are assault-related injuries that often associated with acts of interpersonal and physical violence and mostly require medical attention. [9] Previous studies in the United States noted that poverty and substance abuse (the use of alcohol and drugs in particular) have been closely related to intentional injury and interpersonal violence among adolescents. [9] Children between 13 - 18 years of age show a higher incidence of facial fractures than of those 0 - 6 years of age. [19] In a nationwide community sample study among English children between 4 - 15 years of age the male gender, lower socioeconomic status, single-parent home, Hyperactivity and conduct disorder children were mostly associated with the occurrence of facial injury. [9] Therefore, recognizing some of these markers can be used to identify adolescents at risk and possibly serve as a basis for secondary preventative efforts. [9]

Previous retrospective studies also show the following:

- In contrast with the more constant patterns of facial fracture observed in adults, the wide variety of paediatric injuries represent a combination of mechanical force and anatomic features unique to the child's stage of development; [3, 8, 28]
- Younger children often sustain injuries from low impact/low-velocity forces such as falls and older children are more commonly exposed to high impact/ high-velocity forces; [23, 28]

- Infants below 2 years of age, more often sustain injuries to the frontal region with isolated or non-displaced fractures, whereas older children are more prone to injuries of the chin/mouth region. [28] Thus, with the frontal bone being the most common site of fracture in young children, an increase in frontal sinus fracture after pubertal sinus pneumatisation occurs, which often associated with other facial bone fractures as well as central nervous system involvement. [28]
- The most frequent anatomic distribution of fracture/injury in the lower face comprises the mandible, the mid-face includes the maxillary alveolus, nose, zygomatic bone, maxilla and Le fort I,II,III fractures and the upper face constitutes mostly the naso-orbito-ethmoidal (NOE), orbital and frontal-orbital areas. [25]

TYPES OF FRACTURES

Mandibular fractures

Mandibular fractures commonly occur in several locations depending on the type of injury, direction, and force of the trauma. Mandibular fractures can be classified according to its anatomic location. The fractures are designated as occurring in either the symphysis, para-symphysis, alveolus, body, angle, ramus, neck, condyle or coronoid of the mandible. [30]

Mandibular fractures can also be classified according to the type of fracture which categorizes the fractures either as g*reenstick, simple, comminute or compound.* [30] These categories describe the condition of the bone fragments at the fracture site and possible communication with the external environment.

Greenstick fractures involve incomplete fractures with flexible bone and exhibit minimal mobility on palpation.

A *simple fracture* is a complete transection of bone with minimal fragmentation at the fracture site.

In a *comminute fracture*, the fractured bone is left in multiple segments.

A *compound fracture* results in communication of the margin of the fractured bone with the external environment. Bone would be exposed through the oral mucosa, or soft tissues may be intact when the fracture is in the teeth bearing area. Thus, by definition, any jaw fracture within a tooth-bearing segment is an open or compound fracture.

Mandibular fractures can either be favourable or unfavourable. [30] In a favourable fracture, the direction of the fracture line and the muscle pull (of the masseter muscle) resists

displacement. An unfavorable fracture results in the displacement of the fractured segments from the pull of the masseter muscle. [30]

Earlier studies stated that mandibular fractures in the paediatric subpopulation are relatively prominent, comprise of 20.0% – 50.0 % of all childhood fractures and is reported as the most common facial fracture site. [2, 3, 8, 14, 16, 21 - 23, 26 - 29, 33, 36, 40] The fracture patterns vary with age and although the incidence of condylar fractures is initially high (14.5% - 60.0%) [25] and decrease with age, fractures of mandibular body and angle are initially infrequent but increase with age. [8, 14, 17, 18, 26, 27] The thin neck and highly vascularized nature of the paediatric condyle relate to the increased incidence of intra-capsular condyle fractures in children under the age of 6 years, presenting bilateral in 20.0% of cases. [2, 5, 8, 27, 28, 40] Above the age of 6 years condyle fractures tend to occur more frequently in the sub-condylar and neck region (extracapsular). [28] Symphysis and para-symphysis fractures also seem to be more typical. [28, 30] Strikingly, a large proportion of paediatric patients with mandibular fractures (30.0% – 60.0%) often have serious associated intra-abdominal, neuro-cranial or orthopaedic injuries determined by the force required to result in such injuries. [26]

Midfacial fractures

Midfacial fractures include fractures affecting the maxilla, the zygoma, and the NOE complex. [30] Midfacial fractures can be classified as Le Fort I, II, or III fractures, zygomaticomaxillary complex fractures, zygomatic arch fractures, NOE fractures, palatal and dental alveolar fractures. [30]

Le Fort I fracture: frequently results from the application of a horizontal force to the maxilla, which fractures the maxilla through the maxillary sinus and along the floor of the nose. The inferior portion of the maxilla is separated in a horizontal fashion, extending from the piriform aperture of the nose to pterygoid maxillary suture area, thus separating the maxilla from the pterygoid plates, nasal- and zygomatic structures. [30]

Le Fort II fracture: frequently results from forces that are applied in a more superior position. It involves the separation of the maxilla and attached nasal complex from the cranial base, zygomatic orbital rim area, and pterygoid maxillary suture area, but the zygomatic arches are intact. [30]

Le Fort III fracture: the results when a horizontal force is applied at a level superior enough to completely separate the midface from the cranial base at the level of the NOE complex and

zygomaticofrontal suture area. The fracture also extends through the orbits bilateral and results in a *craniofacial separation*. [30] Mid-facial fractures are isolated or occur in a combination of the above-mentioned injuries. [30]

According to the previous studies, the incidence of midface fractures appears to be infrequent in children and account for 1.2% - 20.0% of paediatric facial fractures. [2, 5, 21, 23, 28] Less than 5.0% appears to be in children under the age of 12 years with the exception of nasal and maxillary alveolar defects. [31] Both nasal and dento-alveolar injuries are often managed in the outpatient setting and are common injuries among children. [1, 33] These injuries seldom appear in the paediatric facial fractures statistics. [2, 30, 27, 28]

The nasal bones are the least resistant of the facial skeleton, constitute nearly 50.0% of all facial fractures in children and are often reported as the most common facial bone fracture in children. [2, 3, 19, 28]

The incidence of dento-alveolar injuries associated with facial fractures has been reported to be as high as 48.0%, especially in children under the age of 10 years. [27] Even an incidence rate of 76.3% from a 10-year study in Austria in 2000 has been reported. [1]

The zygomatic complex fractures appear to be the most common midface fracture in children, [28] with an incidence of 7.0% - 41.0% of zygoma fractures. [2] Le Fort fractures are almost never seen before the age of 2 years, but above the age of 5 years, when the maxillary sinus expands and the permanent teeth erupt, the incidence of mid-face fractures increases. [5, 22, 23, 28] It appears to affect children between 13 to 15 years of age (after 10 years) more often. [5, 22, 23, 28] Greenstick fractures and the elastic characteristics are often displayed in paediatric zygomatic and mid-facial fractures where the fracture lines are often “impacted” instead of being clean breaks with complete displacement. [27] These fractures are often seen with high-energy injuries, are often multilevel and rarely isolated. [27]

Upper facial fractures

Upper facial fractures or injury would refer to the trauma of the roof of the frontal bone, orbit and NOE bones. [25]

Orbital fractures constitute 20.0% (5.0% - 25.0% [31] and 3.0% – 45.0% [2]) of facial fractures in children, often resultant from the transmission of a force directly from the orbital ring to the thin orbital walls, or indirectly from the hydraulic pressure effect of displaced orbital soft

tissues. [28] The orbital cavity itself is bound by the orbital roof, lateral and medial walls, and orbital floor. Some of these boundaries display changes in structural integrity, closely related to the maxillary-, frontal- and ethmoid sinus pneumatisation different stages of development. [2, 21, 31]

Prior to the frontal sinus development, it appears that orbital roof fractures are more apparent in the very young, [27] however, orbital floor fractures are more apparent in older children due to the expansion of the maxillary sinus beyond the equator of the globe. [28] The age at which the probability of an orbital floor fracture exceeds that of an orbital roof fracture is approximately at 7 years of age. [28] Thus, the orbital floor becomes more susceptible to fracture in later childhood. [28, 31] It has been noted in previous studies that associated injuries (to head and neck, neurological such as concussion, depressed skull fractures, intracranial haemorrhage, long bone fractures, pelvic fractures, chest/abdominal trauma) are more commonly found together with orbital fractures in children than in adults. These paediatric patients appear to have more severe associated injuries to the head and chest with a considerably higher overall mortality. [31]

Orbital fractures should be clinically described based on the mechanism of injury, the precise anatomic structures involved and the presence/absence of entrapment. [31] Globe involvement is commonly associated with paediatric orbital fractures and it has therefore been advocated that a thorough eye examination should be performed with orbital injuries which should include the assessment of globe integrity, extra-ocular movements, visual fields, visual acuity and pupillary response. [31] Thus, the acute management of orbital roof fractures is dictated by ocular and neurological signs and symptoms. [27]

MANAGEMENT OF FRACTURES

Treatment of facial fractures in children requires expertise in the acute management of fractures and their associated injuries, as well as an understanding of the age-related facial anatomy and growth biology for long-term follow-up. [27] The anatomical complexity of the developing mandible, for example, the concerns of the compatibility of implanted hardware, often mandate the use of surgical techniques that differ markedly from those used in adults. [36]

With the complications and adverse outcomes related to paediatric facial fractures, Mimi et al have defined three unique types of adverse outcomes that should be considered: [27]

Type 1: those intrinsic to, or concomitant with the fracture/injury itself (i.e., the loss of a permanent tooth with a mandible fracture)
Type 2: those secondary to intervention and surgical management (i.e., marginal mandibular nerve palsy after open reduction and internal fixation of a mandible fracture)
Type 3: those resulting from subsequent growth and development (i.e., asymmetric mandibular growth after a condylar fracture)

With the planning of treatment for paediatric patients, it is critical to consider the adverse effects of post-injury growth disturbances in form and function, especially after severe nasal septum and mandibular condyle injuries. Thus, with treatment, there should be an emphasis on the effect of injury or treatment on growth and development. [13, 25, 34] This has both anatomical, physiological and psychological significance as it may have various effects on the different stages of development. [7, 25, 27] While children are in their developmental phase, there are also special considerations such as behavioural disturbances and nutrition that need to be acknowledged with the planning and treatment of fractures (especially mandibular fractures). [25]

A treatment which includes an anatomic reduction utilizing a wide exposure and rigid internal fixation has been the standard care for adults for a long time, but this method of treatment is seldom effective in children. [26] It is more common and effective to treat facial fractures in children conservatively compared to adults. [21, 28] Conservative management with the use of minimal manipulation is recommended, given the high incidence of non-displaced, minimally displaced or greenstick fractures in children and the greater capacity of the children's skeleton for remodelling. [19, 22, 26] Treatment should be non-invasive whenever possible, and when surgery is necessary the least invasive procedure and least intrusive devices should be used. [5] With paediatric facial fractures that require treatment, accurate reduction with or without fixation should be achieved earlier than in adults, as children's bones heal much faster. [21, 41] Consequently, it has been emphasized that a decision to undertake the surgical reduction of a fracture (especially mandibular) in children, should only be made once the age of the patient and the severity of the fracture have been assessed. [26] Maxillofacial surgical intervention which includes interdental wiring, occlusal splints, drop wires, monocortical plates and screws and bio-resorbable systems, [26] is indicated only for the repair of severely displaced and comminuted fractures that are likely to cause functional impairment, aesthetic deformity or both. [5] With surgical intervention, it is not only essential

to avoid the developing structures during internal fixation, but also to keep debridement and the manipulation of tooth fragments and bone chips to a minimum. [26]

The paediatric dentition also presents a formidable challenge to traditional surgical techniques. [26] Arch bars used for intermaxillary fixation (IMF) in adults may be of little value in children, as the primary teeth and the partially erupted permanent teeth are not a sufficiently stable foundation, for the pressure exerted by the IMF may avulse the primary teeth. [26] The conical shape of the primary teeth with their wide cervical margins and tapered occlusal surfaces, makes the placement of arch bars and or eyelet wires technically challenging. [26, 40] It has been indicated that IMF using arch bars is safe in children older than 9 years. [26] Other studies have reported the use of mini arch bars which exert less strain on the developing teeth. [26]

The department of surgery University of Pennsylvania, reported the use of IMF with arch bars to be safe in patients older than 11 years whose permanent dentition has been able to form adequate roots. But, before the age of 11 years the use of interdental wiring techniques with eyelet wires, for example, is suggested [26] children between 2 - 4 years of age a sufficient number of deciduous teeth is usually present to facilitate the application of arch bars or eyelet wires, whereas 5 – 8-year-olds present with difficulty owing to the loss or loosening of deciduous teeth. [40] Also, due to the thinner mandibular cortex, care should be taken in the placement of circum-mandibular wiring for splints, to avoid pulling a wire through the mandible. [40]

Clinical and experimental evidence have shown that many fractures in children remodel with excellence with little or no intervention and that fibrous union during healing process have shown to be uncommon. [3, 26, 40, 42] The rate of healing also occurs much faster in children, due to the high metabolic rate of most developing tissues and the increased periosteal bone remodelling capacity. [3, 21, 26, 41] This has shown significant truth in many minimally displaced greenstick fractures of the condylar necks that occur early in childhood. [26] It therefore seems that the growth potential of bones in children may serve to improve the long-term results (i.e. as with condylar growth after condylar fractures). [26]

Long-term studies have also shown that children in the stages of deciduous and mixed dentition also demonstrate the capability of spontaneous occlusal readjustment after injury and treatment (even with the imperfect apposition of bone surfaces), by the paediatrics' great remodelling capacity under the influence of masticatory stresses. [26, 40]

Open reduction with rigid internal fixation (mini-plates and screws) has been introduced in the treatment of paediatric facial fractures which increases the chances of a more accurate reduction and fixation of bone fragments, a stable 3-dimensional reconstruction and a decrease in the possibility or need for prolonged maxilla-mandibular fixation (MMF). This treatment permits a rapid return to normal diet, which therefore improves nutrition and tolerance or compliance are also less of a concern. [25, 41] Internal fixation implies some form of open approach with subsequent sub-periosteal dissection, which has the potential to interrupt the bone remodelling potential of the periosteal. [25] Internal fixation with semi-rigid titanium plates is controversial, because a second surgical intervention is required for the removal of the fixation devices. [5] Some authors suggest that semi-rigid fixation with small plating systems (1.0 – 1.3mm outer diameter) currently offer the best fixation alternative and that placement should be done via limited incisions which adequately expose the fracture with removal of hardware 2 – 3 months after placement. [25]

Although the development of microplate and screws made it possible to apply fixation materials in paediatric traumatology, limitations were found in terms of growth restrictions, stress shielding and corrosion. [36] The introduction of the biodegradable plating system for internal bone fixation in children added a new dimension to contemporary treatment and is becoming an alternative treatment in trauma, orthognathic and craniofacial surgery in children. However, the capability of bioresorbable plates to sufficiently bear masticatory loads during fracture osteosynthesis is a matter of concern. [29, 36] Controversial potential problems regarding the use of rigid metal fixation in children include damage to developing teeth, restriction of growth, stripping of excess periosteal bone, scar development, bone elasticity, plate migration, increase in healing capacity of bone, corrosion, secondary surgery and stress shielding. [29, 36]

The department of oral and maxillofacial surgery at the University of Lucknow, India reported: that the use of bioresorbable plates result in a stable fixation; that no growth restriction, complication or unstable fixation under bite force were recorded in the mandible 2 weeks, 1, 3 and 6 months post-operative; that the use of the tripolymer (PLLA/PDLA/PGA/TMC) osteosynthesis system in the management of paediatric fractures involving the mandible and facial middle third gives excellent results in terms of function, aesthetics and acceptability. [29] Another case study from India confirmed a satisfactory long-term result in the use of bioresorbable plates in a 5 year old with a para-symphysis fracture. [36] However, limitations previously reported subject to the use of absorbable plates included

its bulkiness, the larger screws, they absorb over a relative long period of time and that placement requires additional time. [8] One study mentioned that bioresorbable fixation is not recommended for paediatric trauma. [28]

Treatment of mandibular injuries

Mandibular management depends on the fracture site, stage of skeletal growth and dental development. [28] Conservative management with observation is the proposed treatment of choice for:

- Fractures of the mandibular body, angle, ramus and symphysis, when the patient is under 2 years of age; greenstick or minimal displaced bone fractures; the patient without malocclusion or functional deficit; [25, 26, 28]
- Intra-capsular condyle fractures (comminuted or medial pole); high fractures of the condylar neck; greenstick and minimally displaced fractures of the condyle and coronoid fractures; when the occlusion is normal and no barrier to movement exist. [21, 25, 26, 27, 28]

The conservative treatment plan for many paediatric mandibular fractures includes observation, the imposition of a soft diet, rigorous physiotherapy, avoidance of rough physical contact and symptomatic pain control (analgesics). [3, 25, 26, 28, 40] Indicated advantages of conservative management include decreased immobilization time, decreased muscular atrophy, better oral hygiene and a decreased risk of fibrous union or bony ankylosis. [41]

However, in the case of fractures, low in the condylar neck with significant displacement, open reduction with internal fixation is proposed for children over 9 years of age. [26, 27]

Open reduction should be considered: [25, 40] when occlusion cannot be re-established because of the position of the fractured condylar segment or presence of mechanical obstruction; when the segment is displaced in the middle cranial fossa; when a foreign body or penetrating wound is present or avulsion of the condyle into the capsule; with bilateral condyle fractures present in midface fractures or in the case of bilateral condylar fractures together with symphysis or para-symphysis fracture. [28, 36] Bio-resorbable plates can be used for internal fixation, placed along the inferior mandibular border [28, 36] and especially after eruption of the mandibular incisors. [29] Stabilization of the symphysis or para-symphysis can facilitate early mobilization of the mandible with minimal or no need for IMF. [36] Semi-rigid fixation may be considered for an open approach. [25]

Also, with a displaced condylar fracture, a short course (1 - 2 weeks / 7 - 10 days) of MMF or traction with elastics and a soft diet is effective. [25, 28, 40] Young children (the edentulous newborn or the partially edentulous child between 5 - 12 years of age), may be effectively treated with mono-mandibular fixation (by means of an arch bar, acrylic splint or stent, or thermoplastic material fixed via circum-mandibular wires as skeletal suspension) for body and Symphysis injuries. [25] Maxillary-mandibular fixation for a period of 3 - 4 weeks is effective for body, Ramus, angle, or Symphysis injuries is (ideally used for the child between 2 – 6 years of age with 10 teeth in each arch). [25] If semi-rigid fixation is considered, it should be removed in 2 to 3 months to minimize restrictions to growth and development. Ideally, treatment should be initiated 4 - 7 days after injury. [25] It is proposed that open reduction with direct fixation may be used in the body, angle and Ramus. [29]

Treatment of maxillary injury

The maxilla is the least frequent injured facial bone in paediatric patients, which constitutes 1.2% - 20.0% of facial fractures in children. [21, 25, 28] Absolute anatomic reduction is necessary, to ensure proper growth and development with attention directed to the septum, nasal-frontal and nasal-maxillary sutures. [25] Closed reduction with MMF for 2 - 3 weeks to re-establish the occlusion is proposed for minimally displaced fractures. [25, 28] If an open reduction with semi-rigid internal fixation is chosen or needed, the approach should be via a vestibular incision, and occlusion should be optimized afterwards to identify optimal maxillary reduction. [32, 28] If possible, treatment should be initiated within 2 - 4 days. [25]

Treatment of zygoma injuries

Zygoma fractures are relatively frequent in children with an incidence of 7.0% - 41.0%. [25] Proposed treatments require: observation for minimally displaced or greenstick fractures; an open approach for displaced or comminuted fractures; [25, 28] intraoral and Gilles approaches for displaced arch fractures; trans-conjunctivae incisions with lateral canthotomy extensions for most other zygomatic injuries. [25]

Treatment of nasal injuries

Besides alveolar trauma, nasal injuries account for 1.0% - 45.0% of mid-facial injuries in children. [25] Oedema frequently mask nasal fractures which could obscure initial diagnosis. [25, 28] Re-fracture or osteotomy of the healing non-union with definitive treatment would then be required after identification. [25, 28] The definitive treatment includes intranasal packaging with external splinting via an open approach. Although the closed approach is the most

beneficial modality, strict attention to the anatomic reduction of the nasal bones, lateral nasal cartilages, osseous and cartilaginous septum is mandatory. [25] A displaced, but incomplete fracture should be mobilized and treated as a complete fracture. [25]

Growth disturbances are often associated with nasal trauma, especially with failure of adequate treatment of injuries that extend to the nasal-ethmoidal sutures or those that cause premature ossification of the septal-vomerine suture. [25] Although the compliant nature of the paediatric nose makes it less susceptible to fracture, it is most susceptible to soft tissue injuries such as cartilaginous detachment and septal hematoma from direct trauma. [25] Proposed treatment include direct re-approximation and suturing through an open approach or support by intranasal packaging, with incision and drainage of septal hematomas to prevent necrosis and possible growth disturbances. [25, 28]

Treatment of naso-orbito-ethmoidal (NOE) injuries

These injuries occur infrequently with an incidence rate of 1.0% - 8.0%. [25] Observation is acceptable in the highly unlikely incidence of non-displaced fractures. [25] An open approach with precise and anatomic reduction is required with displaced fractures, as growth in this area is dictated by development and suture growth is dictated by the expansion of the cranium to compensate for the brain at the frontal-ethmoidal, frontal-lacrimal, frontal-maxillary, ethmoidal-maxillary, nasal-maxillary and septovomerine sutures.[25] Premature ossification or obliteration of the sutures may result in mid-facial hypoplasia in the vertical and anterior/posterior direction. Therefore, the use of bioresorbable plates and screws can be considered when treating these injuries to minimize the need for secondary bi-temporal incision and flap reflection for the removal of hardware and eliminate hardware migration. [25] If possible, treatment should be initiated within 4 days. [25]

Orbital and frontal bone injuries

Frontal-orbital injuries constitute 2.9% - 35.0% of Paediatric facial fractures. [25] The frequency of isolated fractures varies between 10.0% - 13.0%, orbital floor fractures 25.0% - 58.0%, orbital roof fractures 18.0% - 35.0% and medial wall fractures 5.0% - 28.0%. [25] As mentioned before, the various forms of fracture occur to be age specific. Orbital roof fractures are frequent before 7 years of age, whereas fractures of the internal orbital roof, medial wall, lateral wall, and floor, as with frontal sinus fractures, are common after 7 years of age. [25] Observation is proposed as a treatment in non-displaced or minimally displaced orbital roof fractures without impairment of extra-ocular movement. [21, 25, 28] A neurosurgical consultation should always be obtained. If the bones are displaced, extra-ocular muscle

movements are inhibited or intracranial injury mandates treatment, [25, 29] where an open approach by means of a bi-temporal flap is indicated. [25] General indication for treatment is a large floor defect, greater than 1cm. [28]

Bioresorbable fixation is suggested in order to eliminate secondary, surgical intervention needed for the removal of hardware which can migrate or cause restriction of growth. [25]

After the age of 7 years, it is suggested that most of the internal orbital injuries occur, as growth of the midface is complete. Therefore, in displaced fractures, a surgical approach via open reduction, without the concern of possible growth disturbance can be proposed as a treatment for anatomic reconstruction. [25] A transconjunctival incision and lateral canthotomy extension provide adequate access to the floor and lateral wall at this age. [28] A superior blepharoplasty incision may be required to approach the medial wall or roof. Titanium micro-screws and plates should have no effect on growth at this time. [25] After the completion of growth, some authors are still discouraged by the use of alloplasts for internal orbital reconstruction, although only allergy and intolerance contraindicate their use. Thus, it is advocated that if a concern exists that orbital growth is not complete, bioresorbable mesh, film or sheets are accepted media for internal orbital reconstruction. [25, 28] For best results, treatment should be initiated within 5 - 7 day if possible. [25]

Radiographs

The purpose of radiographs should be to confirm the suspected clinical diagnosis, to obtain information that may not be clear from the clinical examination, and more accurately, determine the extent of the injury.

Radiographic examination should also document fractures from different angles or perspectives. [30]

Radiographic diagnosis of paediatric facial fractures can be confirmed by the following radiographic images: [16, 30, 33]

- Panorex (PAN) view (mandible);
- Townes view (mandible);
- Posterior-anterior (PA) view (mandible);
- Right and left lateral oblique view of the face (mandible);

- Occlusal or peri-apical views (mandible);
- Water's view (mid-face);
- Lateral skull view (mid-face);
- Posterior-anterior skull view (mid-face);
- Submental vertex view / occipital – mental (OM) (Midface);
- CT scans;
- Tomographic views

In case of severe facial trauma, cervical spine injuries should be ruled out with complete cervical spine series x-rays (i.e. cross-table, odontoid and oblique views) before any manipulation of the neck. [30]

CT (computed tomography) is a sophisticated radiographic technique most commonly used for evaluation of mid-facial trauma and are therefore defined as the radiographic imaging technique of choice to confirm the diagnosis of paediatric facial fractures, especially complex facial fractures of the midface and orbit. It provides the ability to evaluate fractures in several planes of space and to visualize the skull, midface, and mandible in three-dimensional (3D), fine and unobstructed anatomic detail.

Thus, with 3D reconstruction, CT scans provide valuable information for the diagnosing, preoperative planning and treatment of complex facial fractures. [28, 30, 31]

ASSOCIATED INJURIES

Concomitant injuries are often associated with facial bone fractures and might include injury, either to the head (brain, cranial vault, skull base), neck (cervical, spine), facial soft tissue (with scalp wounds or soft tissue hematomas), teeth, ocular region or globe. Excessive bleeding with an injury to the head and neck blood vessels, brain contusions, intracranial hematomas, bleeding from the nose, ear or throat, uni- or bilateral involvement of one or more cranial nerves may also occur. Possible thoracic-, abdominal-, pelvis-, upper extremity-, or lower extremity injuries which can include fractures of bones or contusions to specific organs may also be present. [1, 6, 19, 20, 22, 23, 25, 31, 33]

Due to a large cranium to body ratio, paediatric facial fractures are highly associated with injury to the skull and brain. Previous studies have shown a 50.0% occurrence of skull

fractures, especially in children under the age of 6 years, whereas a 5.0% incidence of brain injury has been reported with cranio-maxillofacial trauma. [27]

Teeth injury

Upper incisors are the teeth most commonly affected by trauma in the primary dentition. [1, 11, 12, 13, 35, 43] The average age for the highest incidence of trauma to the primary dentition are children between 1 and 3 years of age (2 – 4 years [10]) due to the development of motor coordination. [1, 12, 43] The type of trauma that occurs in children is generally age-related. [43] The prevalence of traumatic injuries to permanent teeth has been reported to vary at a rate of 7.3% and 58.6%. [32] The rate of incidence seems to increase with age. [10, 11, 32] Some studies have shown a peak in the fracture incidence of permanent teeth from 8 - 13 years of age, which they seem to stabilize, [11] or in children 6 and 8 - 10 years of age. [32] The great variation reported by previous studies may be attributed to a number of factors that include the type of study, trauma/diagnosis, classification, methodology, study size and population, geographic location and differences in cultural behaviour. [11, 12, 24, 32]

Injuries to permanent teeth which are common injuries in the maxillofacial region often result in pain with functional, aesthetic and psychological consequences. [11, 12, 24, 32] The maxillary incisors are the most commonly affected in dental trauma [1, 11, 12, 28, 34] followed by upper and lower lateral incisors and the upper canines. [13, 32] However, the rate of incidence in the maxillary incisors is significantly higher, most possibly due to their exposed position in the dental arch. [32] Trauma to the permanent incisors show a high prevalence in children 7 - 12 years of age (some studies indicate a peak in 8 - 10 and 9 - 11 years of age [34]), with a predominance in male children, [10, 12, 32] children with a protruded maxilla and children with a pronounced overjet. [11, 15, 24, 32] According to the literature, crown fractures are the most common trauma of permanent maxillary incisors, often reported in older children. [12, 32]

Other studies show that enamel/enamel-dentine fractures are more evident. [10, 32] Reports from various studies, however, indicate that unspecified accidental falls are the most common cause of dental injury. [10, 12, 24, 32]-

As presented by Sanders et al., dentoalveolar injuries can be classified into: crown craze or crack; horizontal or vertical crown fracture; crown-root fracture; horizontal root fracture;

sensitivity (i.e. concussion); mobility (i.e., subluxation or looseness); tooth displacement (intrusion, extrusion, labial displacement, lingual displacement or lateral displacement); avulsion; alveolar process fracture [1, 2, 12, 30:box 24.1]

Luxation/displacement, subluxation, and avulsion of the incisors appear to be the most common type of injury in the primary dentition. [10, 12, 13, 34, 43] This most possibly relates to the pliability of the facial skeleton and of the periodontal ligament, the large volume of teeth in relation to the bone in the primary and mixed dentition and also the shorter roots of the primary teeth. [10, 34, 43]

The consequence of trauma to primary teeth often includes colour change, pulp necrosis, obliteration of the pulp canal, gingival retraction, displacement of primary teeth, pathological root resorption, alterations in the process of physiological root resorption, or premature loss of the primary tooth. [43]

The aim of the diagnosis and treatment of traumatic injury to primary teeth should be pain management, to prevent sequential complications of the developing permanent tooth germ and long-term prognosis of the permanent tooth. Therefore, treatment of intrusive injuries in the primary dentition should include determination of the relationship between the primary and permanent teeth. [43] The anomalous development of permanent teeth, which either include the coronal part, root region or whole of the permanent tooth germ may result as a complication from an intrusive injury (impact of force in an axial direction that results in a displacement of the tooth within the socket) to primary teeth. [43] When a child is between 1 and 3 years of age, the severe intrusion of a primary tooth may result in malformation of the permanent tooth, due to the invasion of the earliest phases of odontogenesis in the developing tooth germ. [43] This is when the medial and incisal thirds of the enamel matrix take place. [43] Development of the permanent tooth may also be altered in the secretory phase of the ameloblasts or in subsequent stages, changing the root formation process. [43]

Sequential complications in permanent teeth that often affect: the coronal region include structural alterations with associated enamel hypoplasia, crown dilacerations and white, yellow or brown discoloration, [43] those affecting the root region often includes root duplication, root dilacerations and partial or complete arrest of root formation and those complications affecting the whole tooth germ may either include alterations in the process of eruption of the permanent tooth, retention of the permanent tooth or malformation of the permanent tooth germ giving the appearance of an odontoma (any tumour of odontogenic

origin or a mixed tumour of odontogenic origin, in which both the epithelial and mesenchymal cells exhibit complete differentiation resulting in the formation of tooth structures) [43]

Globe or ophthalmic involvement

Reports have shown an increased likelihood of up to 50.0% of associated ocular trauma with midface and frontal region fractures and associated blindness due to a traumatic optic nerve injury or a ruptured globe with orbital and mid-facial fractures. [27] It has been emphasized that identification of non-reactive pupils and afferent papillary defect is of utmost importance in the prediction of serious eye injury. A formal ophthalmic consultation is highly recommended in children with facial fractures, specifically with both blunt and penetrating eye injuries. [27] Associated post-traumatic nerve injury often occur in children with facial trauma. [27] Nerve impairments that frequently occur in conjunction with fracture displacement or surgical intervention fractures are: infra-orbital dysesthesia (associated with orbital blowout fractures); infra-orbital nerve dysfunction (associated with zygomatic-maxillary complex fractures); taste and olfactory disturbances (associated with middle and lower third facial fractures); facial nerve palsy and ophthalmic nerve palsy; sensory nerve disturbances have been reported to range from 3.8%–23.9%. [27]

Facial soft tissue injury

Soft tissue injuries, often shown as the most associated facial injuries in children, [33] occur in as many as 29.0% - 56.0 % of facial fracture cases and are often overlooked. [1, 27] These wounds would often lead to poor scarring as an adverse outcome. [27] Management principles are much the same as for adults, although treatment if possible should be initiated within hours due to occurrence of sooner healing. [25] Basic principles of soft tissue injury include cleansing and debridement of the wound, hemostasis and closure of the wound, with a prescription for post-operative medication if necessary. [8, 25, 27, 30]

Typical traumatic soft tissue injuries sustained by children: [2]

- Contusions (also called a bruise, caused by trauma inflicted with a blunt object, indicates tissue disruption within tissues, which result in subcutaneous or submucosal haemorrhage, without a break in the soft tissue surface / skin) [30]
- Lacerations (a tear in the epithelial and sub-epithelial tissues commonly caused by a sharp object, if the object is not sharp, the laceration might be jagged) [30]

- Abrasions (a wound caused by friction between an object and the surface of the soft tissue, usually superficial, denudes the epithelium and occasionally involves deeper layers) [30]
- Avulsion (ripping or tearing away of a part either accidently or surgically);
- Transfixion (cut from within outwards)
- Animal bites
- Puncture wounds
- Gunshot wounds
- Burns

Although facial lacerations are noted to be the most common associated injury, [23, 34] extensive and devastating paediatric soft tissue injuries often occur from animal bites. [2, 25] Approximately 8.0% of all bites on the body occur in the head and neck area and primarily affect the lips and cheek. Most of these injuries occur in children between 5 – 10 years of age. [44]

Soft tissue injury could commonly result in keloids and hypertrophic scars, although better cosmetic results are often achieved from the immature collagen of children's soft tissue. [1, 25, 34] Specialized structures, such as the facial nerve and salivary ducts, may require microvascular repair or in case of a nasolacrimal duct laceration, dacrycostorhinostomy stent should be placed for 2 - 3 weeks. [25]

Psychosocial counselling may be required for paediatric patients sustaining this form of traumatic facial injuries, consequently for the trauma and the deforming nature of the soft tissue injury. [25]

CHAPTER 3: RATIONALE

Recent reports from studies done in South Africa regarding maxillofacial fractures in children were documented in 1996 from a study done at the University of the Witwatersrand (WITS) in Johannesburg [33] and in 2006 from a study done by the department of paediatric surgery, University of Cape Town (UCT). [45] It is therefore important to undertake this study, nearly 20 years later at the Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) to determine the current prevalence and management of facial fractures in children under 15 years of age. The findings of this study were significant in terms of providing a trend (baseline data) for the planning of treatment, for possible resources (including financial, budgeting and possible human resources) of facial fractures/injuries in children and for the comparison of expected demographic changes in the future (e.g. opening of Nelson Mandela Children's hospital) and also to have compare our results with similar studies globally.

AIMS AND OBJECTIVES

AIM

The aim of this study was to determine the prevalence, with associated injuries, methods of treatment and management of traumatic facial fractures in children under the age of 15 years who were presented to the CMJAH (department of maxillofacial and oral surgery, Wits Oral Health Centre and the department of general surgery) over a period of 5 years from 2011 to 2015.

STUDY OBJECTIVES

The objectives of this study for patients under the age of 15 years were:

- To determine the prevalence of facial bone fractures;
- To determine the age, gender and ethnicity mostly affected;

- To determine the place with the highest risk of injury;
- To determine the most frequent causes of facial fractures;
- To determine the most frequent type and anatomical distribution of facial bone fracture;
- To determine the prevalence of associated injury (soft tissues, dental, ocular and rest of the body);
- To describe the management of facial fractures, regarding the various treatment modalities.

CHAPTER 4: METHODOLOGY

4.1 Materials and methods:

The file numbers of the paediatric patients were retrieved from the annual admission books of the departments of general surgery and the paediatric casualty ward from 2011 to 2015. The file numbers retrieved were of children who have been registered or admitted for facial or head injury, or associated facial or head trauma which either included skull fracture; concussion; head injury; facial bone fracture; burns; facial swelling; submental or submandibular swelling; cheek swelling; facial bleeding; facial soft tissue injury; blunt trauma to face/head; facial/head lacerations, intra-/extra-oral injuries; teeth injuries; eye trauma; intra/peri-orbital injury/trauma; epistaxis or nasal associated injury; facial/head haematoma; extra/subdural haemorrhage; degloving head injury; temporomandibular joint (TMJ) dislocations or incidents which could have led to facial/head trauma, such as a motor vehicle accident (MVA), pedestrian-vehicle accident (PVA), fall from height (FFH), sporting injury, assault, violence or gunshot wounds, abuse, dog bite/rat bite or injury from an object to the face. Many previous research studies did not distinguish between MVAs and PVAs as an etiological factor, whereas in this study MVAs and PVAs as a cause of paediatric facial fractures were considered as two separate entities in the data analysis.

These patient files were then analysed. Some of the patient files from the 2015 were stored electronically and could be scanned on a computer, whereas the rest of the files of 2015 and the files from 2011 to 2014 were stored in hard copy and had to be scanned manually in a lightbox.

Various sites of facial fracture were recorded in the patient files which included either one or more of the following facial bones:

- *Frontal bone*. Most of the frontal bone fractures were either associated with the sphenoid-, orbital-, zygomatic-, parietal-, temporal- or ethmoidal bones. Thus, frontal fractures were recorded as frontoparietal, fronto-orbital, fronto-zygomatic, fronto-sphenoid, fronto-temporal or fronto-ethmoidal.
- *Orbital bone*. The orbital bone fractures were recorded in relation to the border of the orbit, which either included the superior, inferior, medial or lateral border with or without the inclusion of the laminae papyrycea.
- *Zygomatic bone*. The zygomatic bone fractures were recorded according to its relation with the arch, zygomatic-maxillary complex, fronto–zygomatic suture, tempero-zygomatic suture and the maxilla.
- *Maxillary bone*. These fracture sites either included the maxilla or maxillary-alveolus.
- *Palatal bone*
- *Mandibular bone.* Mandibular fractures were recorded according to the specific anatomical site of the bone, which either included the symphysis, body, angle, ramus, neck, para-symphysis, alveolus, condyle or coronoid of the mandible.
- *Nasal bone*.
- *Le Fort fractures* were also recorded. These fractures were indicated as either Le Fort I, II or III.

4.2 Study design:

This was a retrospective study based on data retrieved from patient records.

4.3 Study population and Sample

i. **Site of study:** Charlotte Maxeke Johannesburg Academic Hospital. (CMJAH)

ii. **Study population:** Children under the age of 15 years with facial bone fractures, who was presented at the department of maxillofacial and oral surgery (MFOS), the Wits Oral Health Center and the department of general surgery.

iii. **Subgroups:** The children have been grouped into subgroups of age, in order to correlate the site of facial fractures with the stage of development. The age subgroups ranged from 0 – 5 years, 6 – 10 years and 11 – 15 years of age.

iv. **Sample size:** The estimated sample size of 104 (Epi – info 7) over the five-year period from 2011 till 2015 were calculated by a hypothesized 60.0% frequency of

outcome factor and confidence interval of 95.0%, whereas the actual sample size of this study resulted in a total of 171 after the analysis of the current existing clinical files.

v. **Inclusion criteria:**

All children under the age of 15 years with facial fractures were included in the study.

Exclusion criteria:

Children above 15 years of age and adults were excluded from this study.

4.4 Data collection

The data collected were retrieved from the patient records of those children under the age of 15 years who presented with traumatic facial fractures at the CMJAH (department of maxillofacial and oral surgery, the Wits Oral Health Center and department of general surgery selectively) over a period of 5 years, from 2011 to 2015.

The following data were collected: department of admission; date of admission; age; gender; who accompanied the patient to hospital; ethnicity; medical history; number of days between date of injury and date of arrival; place of injury; cause of fracture; site of fracture; type of fracture; teeth affected; associated facial injuries; ophthalmic or globe involvement; associated bodily injuries; specialized consultation; radiographs; management and treatment of injuries. The data were then transferred and categorized into an extensive tabulated data collection sheet. (Appendix A) From the collection sheet data was columned to an Excel spreadsheet and then into a statistical software version.

4.5 Data processing and analysis

IBM SPSS statistical software version 23.0 (R) was used for all statistical analysis, with the level of significance at 5.0%. The associations between categorical variables and traumatic facial fractures were tested using Pearson's Chi-squared test. The Fischer's exact test was used for variables that had an expected frequency of five or less. Logistic regression was used to identify factors associated with traumatic facial fractures and odds ratios were used to determine the strength of associations.

4.6 Limitations

Limitations included: lost file numbers, incomplete admission books, lost files or files that were unable to retrieve, incomplete patient records, patient records with information that showed a variance in the quality and information on patient records that was difficult to interpret.

ETHICAL CONSIDERATIONS

Ethical Clearance

Ethical clearance was approved by the University of Witwatersrand Human Research Ethics Committee, with certificate number: M150833 (Appendix B).

Permission was granted by the Clinical Director of the CMJAH (Appendix C), CEO/Head of Wits Oral Health Centre (Appendix D) and Clinical Head of the Department of Surgery (Appendix E).

Patient confidentiality

A reference number was allocated to each patient file to maintain patient confidentiality.

CHAPTER 5: RESULTS

Five thousand four hundred and eighteen (5418) file numbers of children with facial or head trauma were retrieved from the hospital archives of which 1282 file numbers were excluded. These file exclusions neither included nor associated with facial fractures. (Table 1)

Table 1 shows that 4136 files were retrieved for the analysis of this study.

Included year of study	Number of files retrieved from year of study
2011	865
2012	936
2013	875
2014	637
2015	723
Total files	4136

Ninety two files were not found. Thus, from the analysed 4044 files a total of **171** cases of children under the age of 15 years with facial bone fractures was retrieved from patient records.

Department

Children with facial bone fractures who arrived at the paediatric casualty ward of the CMJAH was admitted and then transferred accordingly to either one of the two departments: department of maxillofacial and oral surgery and the department of general surgery. Twenty seven (15.8%) patients were managed in the department of maxillofacial and oral surgery whilst 115 (67.3%) patients were managed in the department of general surgery. Twenty nine (16.9%) patients were managed and treated by both departments.

Gender

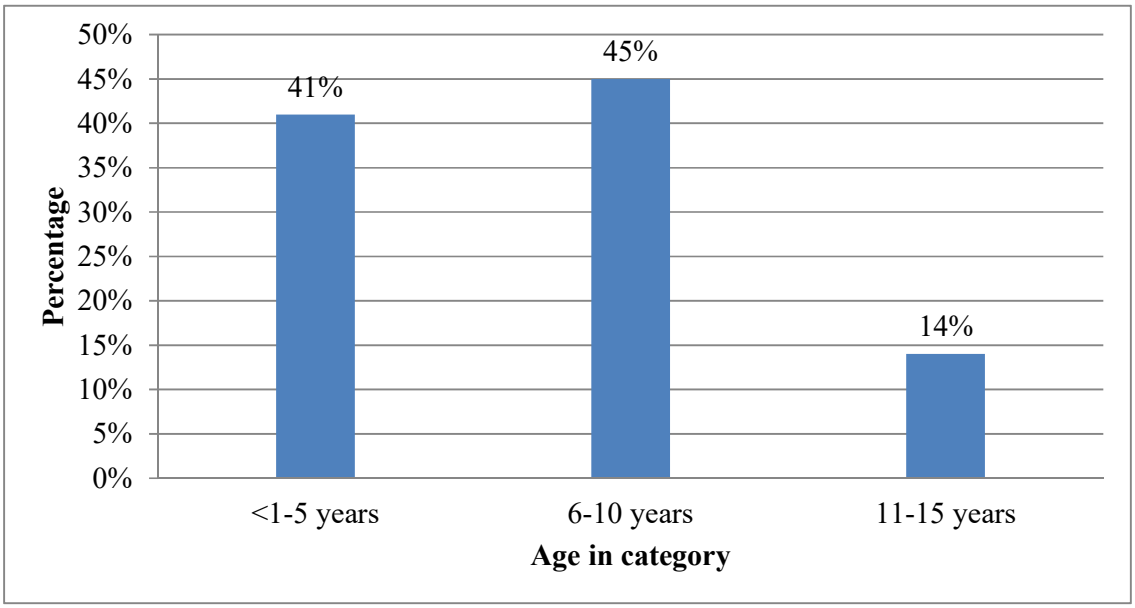
One hundred and nine (63.7%) patients were males, with 62 (36.3%) being females. In males, the facial fractures were primarily due to falls, pedestrian-vehicle accidents (PVAs), motor vehicle accidents (MVAs), sports injury, violence and by an object to the face, whereas in females, the major causes of facial fractures were mainly due to PVAs, falls, MVAs and violence.

Referral

One hundred and twenty-seven (74.3%) patients were brought to the hospital by their parents, 42 (24.5%) by emergency medical services and 2 (1.2%) children were admitted to the hospital by their guardian.

Age

The mean age was 6.45 ± 3.47 years. Figure 1 shows the prevalence by sub groups of age. A higher incidence of facial bone fractures was noted amongst children below the age of 10



years.

Figure 1 shows age category of patients

Ethnicity

The ethnic groups represented amongst in this study population were mostly from various African nationalities. The Black African racial group was mostly represented with 139 (81.3%) children. Twelve (7.0%) White / Caucasian patients were recorded, with 11 (6.4%) patients that descended from Indian nationality. No Coloured patients were detected in this study. A total of 9 (5.3%) paediatric patients were from other nationalities.

Medical History

The majority of children had no underlying predisposing medical condition. One hundred and sixty-six (97.0%) paediatric patients in this study were healthy. Single cases (0.6%) of patients with asthma, ADHD and deafness were reported while 2 (1.2%) patients declared a history of epilepsy.

Date of arrival

One hundred and forty three (83.6%) patients were admitted to the CMJAH on the same day of injury. Twenty-six (15.2%) paediatric patients were admitted to hospital between 1 and 42 days after the date of injury, whilst 'date of injury' was not indicated in the records of 2 (1.2%) patients.

Place of injury

The most familiar places children obtained facial fracture injuries were at home or at school (which include the day care centers). Seventy-three (42.7%) paediatric patients were injured at home or close to home, whilst further reports showed that 23 (13.4%) children were injured at school or nearby the school environment. Seventy-five (43.9%) patients were injured elsewhere, in other places. Other places of injury, refer to any other environment, surrounding area or public place in the home or school. Note: the various road sites around / nearby the home, school or other places, where motor vehicle accidents occur, were included in those specific places of injury.

Date of arrival

Most cases were reported in 2012 and 2013. In 2011, the facial fracture was fairly equally distributed between 2-4 cases per month. Only in the month of September 2011, no case was

reported. In 2012, most case reports were in June with the lowest rate between May and September. The most cases in 2013 were admitted in December whilst April to September showed the lowest rate of incidence between 0 - 2 patients per month. In 2014 the most cases were recorded in January and April, with the minimum number of facial fracture injuries between August and October. In 2011 and 2015, case reports varied between 1 – 4 cases per month, with a peak in incidence in April 2015. Thus, a general peak in incidence occurred between the months of January to March/April and October/November, as opposed to the lower rate of injury in the 2 months of May and September.

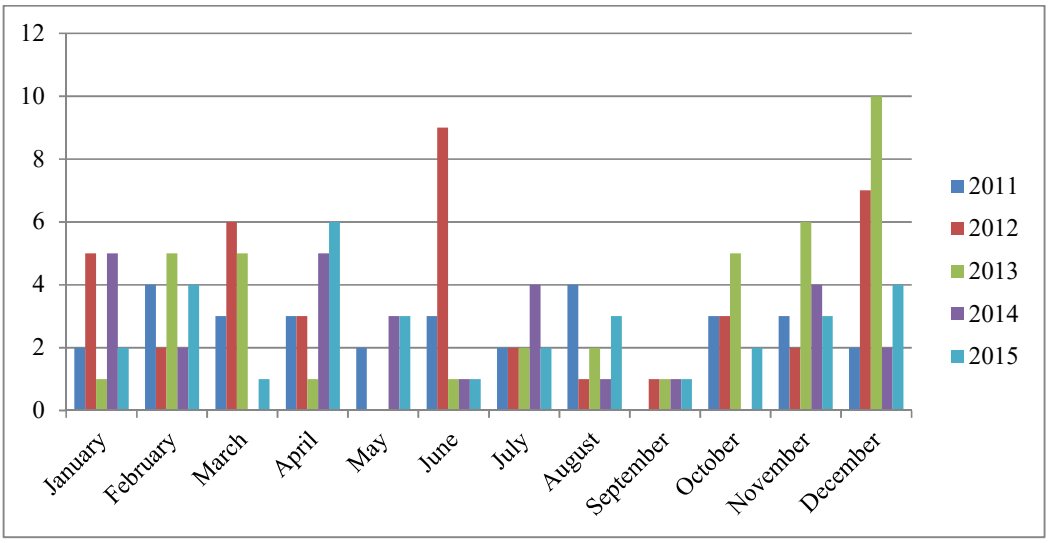


Figure 2 shows the monthly distribution of paediatric facial fractures in each year

Causes of fractures

As shown in Figure 3, the most common causes of facial bone fracture injury were:

- Motor vehicle accidents (MVAs)
- Pedestrian-vehicle accidents (PVAs)
- Falls or fall from height (FFH)
- Sport injuries
- Abuse
- Violence
- Bicycle accidents or
- Other injuries such as being hit by gate or with an object on the face

The cause of facial fracture was not indicated in 3 (1.8%) of the 171 patient records.

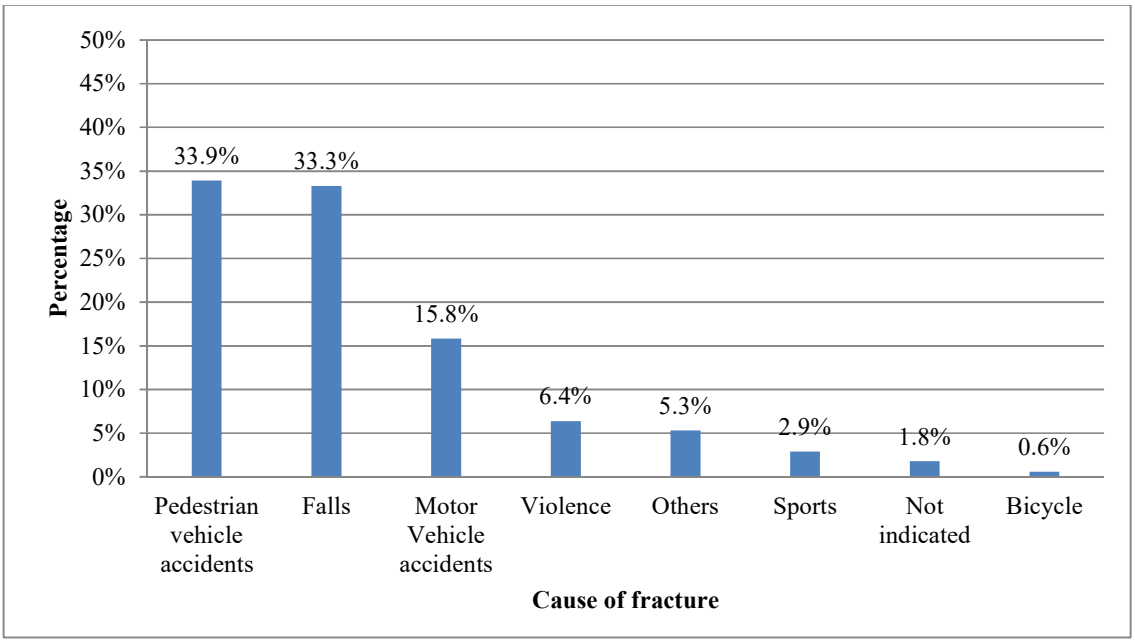


Figure 3 shows causes of fractures among the patients (N=171)

Others: **comprise of facial fracture injury due to being hit by a gate or an object on the face.**

Of the 58 paediatric patients that obtained a facial fracture injury due to involvement in a PVA, 21 (33.9%) were female and 37 (33.9%) were male. The PVA incidence regarding male and female was notably the same. The number of children that were involved in a MVA concluded to 27 cases, of which 13 (21.0%) were female and 14 (12.8%) were male. Although the number of males compared to females involved in MVAs was almost the same, the incidence rate amongst females was much higher.

Eighteen (29%) females and 39 (35.8%) males sustained a facial fracture injury due to a fall or by falling from a height. The facial fracture incidence due to falls was much higher in males. One (0.9%) male patient obtained a facial fracture injury due to a bicycle accident whilst 5 (4.6%) paediatric males were admitted with sports-related facial fracture injuries. Neither bicycle nor sports injuries were noted amongst females. Seven (11.3%) female patients and 4 (3.7%) males obtained a facial fracture injury due to violence, which therefore indicates a 7.6% higher incidence rate in female children, than in males. Seven (6.4%) males compared to 2 (3.2%) females were hit by an object or a gate on the face, which conclude to a

50.0% higher rate of facial fracture incidence due to other causes amongst males, than in female children.

For the purpose of this study, children were grouped according to age into age-related sub-groups. The aim of these relevant sub-groups was to determine the distribution of the cause, type, and site of fracture according to age.

As illustrated in Table 2, PVAs were the major cause in sub-groups 6 – 10 years and 11 – 15 years of age. PVAs were second most to falls, the greater cause of injury in children between 0 – 5 years of age. Although PVAs were the major cause of facial fracture amongst children 6 – 10 years and those 11 – 15 years of age, the total number and incidence of PVAs in children 0 - 10 years of age, was the highest. MVAs were second to PVAs, the major cause of facial fracture in children 11 – 15 years of age. Although the 6 (25.0%) children affected by MVA in the age group 11 – 15 years of age is less than the 13 (16.9%) children 6 - 10 years of age and the 8 (11.4%) children younger than 5 years of age, the MVA incidence is higher in children older than 10 years of age. Less children 0 – 5 and 6 – 10 years of age obtained a facial fracture injury due to MVA than of PVA or falls. The MVA incidence amongst children in this study has increased with age. Patient records did not reveal whether passengers were restrained or fastened by a seatbelt at the time of the accident.

Falls were the major cause of facial fracture in children 0 - 5 years of age and the second major cause in children 6 – 10 years of age, but only 2 (8.3%) patients 10 – 15 years of age obtained a facial fracture due to falls. In this study, the incidence of falls as the major cause of facial fracture in children decreased with age.

The bicycle associated facial fracture injury was detected in a single patient (1.3%), in the sub-group 6 – 10 years of age. Sports-related facial fracture injuries occurred in 2 children between 6 – 10 and 3 children 11 – 15 years of age. Although the total number of patients affected in these particular sub-groups of age were almost the same, the 12.5% incidence amongst children above 10 years of age were much higher than the 2.6% incidence in children 6 – 10 years of age.

Violence affected children in all sub-groups of age with an almost equal distribution in the number of cases per age group. However, the incidence of violence varies, especially among children younger than 10 years and those older than 10 years of age. A lower incidence rate were detected in children 0 - 5 years and those 6 – 10 years of age, whereas a higher

incidence due to violence was detected in children 11 – 15 years of age. Violence as a cause, thus has a greater effect on older children in this study.

Children admitted with facial fractures due to being hit by a gate, were remarkably recorded in all ages related sub-groups, although the incidence was considerably low compared to other causes of facial fracture. One child (1.3%) in the sub-group 6 – 10 years of age, obtained a facial bone fracture due to an object that accidentally got stuck in the face.

Table 2 shows causes of fractures according to age

	<1-5 years		**6-10 years**		**11-15 years**	
Cause of fracture	**N**	**%**	**N**	**%**	**N**	**%**
PVA	22	31.4	29	37.6	7	29.2
MVA	8	11.4	13	16.9	6	25.0
Fall	31	44.3	24	31.2	2	8.3
Bicycle	-	-	1	1.3	-	-
Sports	-	-	2	2.6	3	12.5
Violence	4	5.7	3	3.9	4	16.7
Hit with gate	3	4.3	3	3.9	2	8.3
Object stuck to face	-	-	1	1.3	-	-
Not indicated	2	2.9	1	1.3	-	-
Total	**70**	**100**	**77**	**100**	**24**	**100**

Statistical analysis

The Fischer's exact test which is a bivariate measure of association was used to determine the association between the dependent and the independent variables.

Table 3 illustrates the association between place, year and cause of fracture and demographics

Demographics	Place of fracture	Year of fracture	Cause of fracture
Age	0.19	0.73	0.01
Gender	0.08	0.48	0.08

There was a significant association between the cause of fracture and the age of the patients ($p<0.05$). Place and year of fracture showed no significant association with age and gender ($P>0.05$)

Table 4 demonstrates the association between place, year, cause, and site of fracture and demographics

Demographics	Place of fracture	Year of fracture	Cause of fracture	Site of fracture
Age	0.19	0.73	0.01	0.98

Gender	0.08	0.48	0.08	0.27

Place, site and year of fracture showed no significant association with age and gender (P>0.05)

Table 5 shows the multinomial logistic regression between the cause of fracture and the age of the patients using the age category 11-15 years as a reference

Age category	Exp (B)	P value Sig.	95%CI
<1-5 years			
MVA	2.31	0.15	0.75-7.15
Fall	15.50	0.00*	2.83-85.01
Others	-	-	-
6-10 years			
MVA	2.64	0.08	0.90-7.77
Fall	9.82	0.01*	1.81-53.22
11-15 years			
MVA	Ref	Ref	Ref
Fall	Ref	Ref	Ref

As shown in Table 5, the results showed that children younger than 5 years of age were approximately 16 times more likely, and those children between 6 – 10 years of age almost 10 times more likely to sustain a facial fracture injury due to falls than children 11 – 15 years of age.

Site of fracture

There were altogether 247 facial bone fractures amongst the 171 paediatric patients. As the most familiar site of the facial bone fracture, 74 (30.0%) frontal bone fractures were detected. The 53 (21.5%) orbital fractures concluded to be the second most common site of facial fracture. Thirty-nine (15.8%) maxillary and 37 (15.0%) mandibular fractures were noted. Twenty-seven (10.9%) fractures of the nasal bone and 12 (4.9%) zygomatic bone fractures were recorded. The 3 (1.2%) Le Fort fractures (1 x Le Fort I and 2 x Le Fort II) together with the 2 (0.8%) palatal fractures result to 2.0% of all the paediatric facial fractures. (Figure 4)

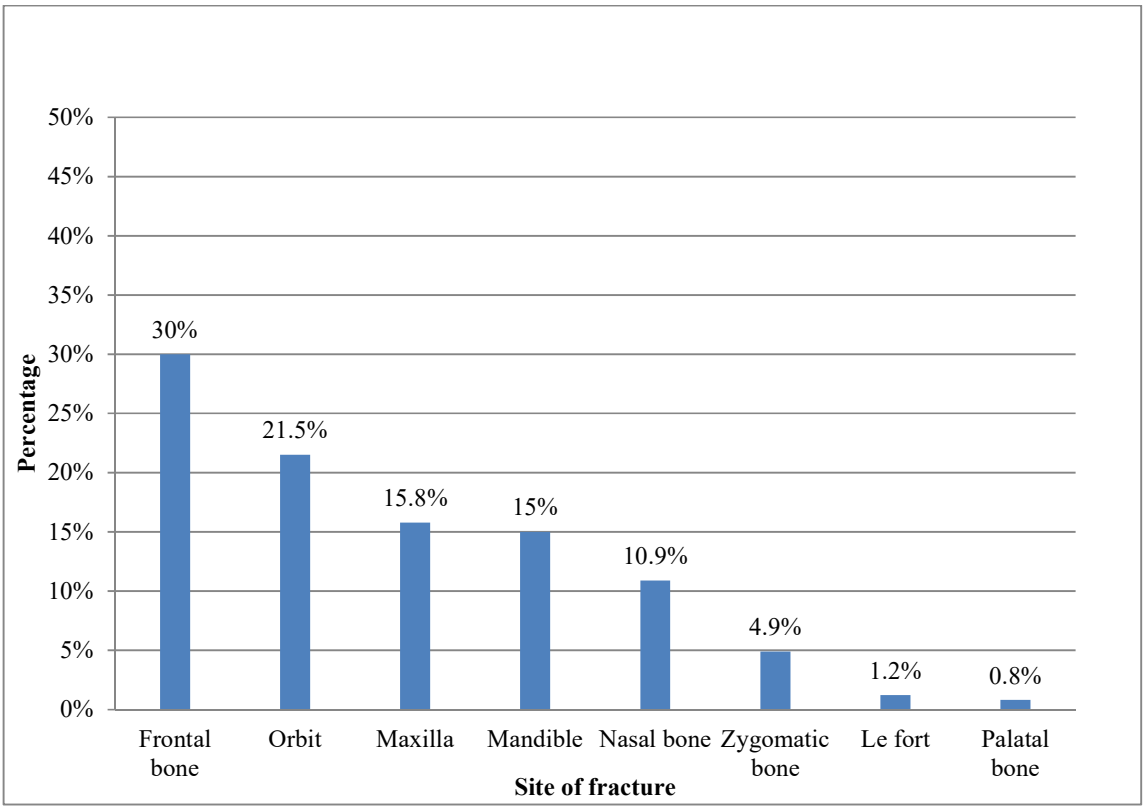


Figure 4 shows site of fracture (N=247)

Of all the frontal bone fractures, 38.0% were associated with the orbit, 22.0% with the parietal bone, 16.0% with the sphenoid bone, 12.0% with the ethmoid bone and a 6.0% association in both the zygomatic and temporal bones.

Thirty-seven percent of the orbital fractures occurred on the superior border, with 20.0% indicated in the inferior border. Twenty-eight percent and 15.0% of the orbital fractures included the medial wall/laminae papyrycea and lateral wall respectively.

Zygomatic arch fractures were included in 38.0% of the zygoma injuries whilst 12.0% comprised the zygoma-maxillary complex. Both the fronto-zygomatic and tempero-zygomatic sutures showed a 25.0% involvement in zygoma fractures.

Eighty-six percent of all maxillary fractures involved fracture of the maxillary alveolus.

Parts of the mandible that were mostly fractured included the condyles (30.0%), body (24.0%) and symphysis (20.0%). Eight and a half percent of all mandibular fractures included the para-symphysis whereas the angle, neck, alveolus, and coronoid of the mandible respectively showed a less than 6.0% fracture involvement.

Of the 247 recorded facial fractures, 102 fractures were noted in children 0 - 5 years of age, 110 fractures in the paediatric sub-group 6 - 10 years of age and the least number of 35 fractures were detected in children 11 - 15 years of age. (Table 6)

Most of the frontal bone fractures occurred in children under the age of 10 years, especially in those patients 0 - 5 years of age. The highest number of orbital fractures was in children under the age of 5 years and showed a similar result than frontal fractures with age. Thus, a decrease in frontal and orbital fracture incidence appeared with age

More zygomatic and maxillary bone fractures occurred amongst patients under 10 years of age, mostly in children aged between 6 – 10 years. However, the 5.5% and 5.7% zygomatic fracture incidence, as well as the 17.3% and 17.1% maxillary fracture incidence in children 6 – 10 years and 11 – 15 years of age were closely ranged. The zygomatic and maxillary fracture incidence was least in children between 0 – 5 years of age.

The total number of mandibular fractures appeared mostly in children under 10 years of age and there was an almost equal fracture distribution in numbers amongst all ages under 10 years. However, the rate of mandibular fracture incidence was the highest in children 11 – 15 years of age with 17.1%, followed by 15.7% in children 0 – 5 years of age and 13.6% in those patients 6 – 10 years of age.

A 1.8% palatal bone fracture incidence was only detected in patients between 6 – 10 years of age. More nasal bone fractures were recorded in patients above 6 years of age, although the highest incidence was detected amongst children 11 – 15 years of age. The nasal bone fracture incidence increased with age. Two Le Fort fractures were noted in children under the age of 5 years with one such fracture noted in a child above 5 years of age.

Table 6 illustrates the site of fractures according to age

	<1-5 years		**6-10 years**		**11-15 years**		
Site of fracture	**N**	**%**	**N**	**%**	**N**	**%**	**Total (n)**
Frontal bone	35	34.3	32	29.1	7	20	74
Orbit	26	25.5	22	20	5	14.4	53
Le fort	2	2	1	0.9	-	-	3
Zygoma	4	3.9	6	5.5	2	5.7	12
Maxilla	14	13.7	19	17.3	6	17.1	39
Palatal bone	-	-	2	1.8	-	-	2
Mandible	16	15.7	15	13.6	6	17.1	37
Nasal bone	5	4.9	13	11.8	9	25.7	27

Total	**102**	**100**	**110**	**100**	**35**	**100**	

From a gender perspective, a significant number of 156 facial bone fractures were recorded amongst the 109 male patients, whilst 91 facial fractures were noted amongst the 62 females. The incidence of frontal bone fractures was 29.5% in males compared to 30.8% in females. Orbital fractures were identified in 20.5% of males and in 23.1% of all females. Sixteen point seven percent of all facial fractures in males were detected in the maxilla followed by a 14.3% occurrence in females. A 15.4% mandibular fracture incidence was noted in males compared to the 14.3% in females. Ten point three percent of all males and 12.1% of all females had nasal fractures, with the zygomatic fractures showing a much lower incidence of 5.1% in males compared to 4.4% in females. One palatal fracture was noted in both a male (0.6%) and a female (1.1%) patient with 3 (1.9%) Le Fort fractures identified in male patients only.

Although a greater difference in the number of facial bone fractures was noted between male and female children, the fracture incidence of various bone sites between male and female was closely ranged.

Types of fractures

Of the 247 facial bone fractures, 115 (67.3%) of the 171 patients had a linear fracture compared to the 56 (32.7%) patients that had multiple facial bone fractures.

Most patients, which resulted in 121 (70.8%) had a fracture/s that were non-displaced whilst 39 (22.8%) patients had a displaced fracture/s. The type of fracture in terms of displacement was not indicated in 11 (6.4%) of the patient records.

Also, 2 (1.2%) patients had a compound fracture whereas the fractures of 30 (17.5%) children were comminuted. The fractures of 4 (2.4%) patients showed clinical or radiographic signs of crepitus.

Seventy-five (68.8%) males and 40 (64.5%) females had a single linear fracture, whereas 34 (31.2%) males and 22 (35.5%) females showed signs of multiple fractures. This indicates a fairly similar linear and multiple fracture incidence amongst male and female. An equal number of compound fractures (1 x male; 1 x female) and fractures with signs of crepitus (2 x male; 2 x female) were noted in both male and female patients, although a 3.4% higher incidence of compound fractures and almost double the rate of crepitus incidence in females

were noted. The incidence of comminute fractures was almost 10.0% higher amongst the males.

The 19 (31.1%) displaced fractures detected in females almost correspond to the 20 (20.2%) noted in males, but show a higher rate of incidence, whereas a higher incidence of non-displacement were noted in the 79 (79.8%) males, compared to the 42 (68.9%) females.

Most linear fractures appeared in children 6 - 10 years of age, followed secondly in children 0 - 5 years of age. Although the 16 (66.7%) linear fractures documented in children 11 - 15 years of age were much less in number than detected in patients under 10 years of age, the rate of incidence was fairly similar in all sub-groups of age. Over against that, the incidence of multiple fractures also corresponded in each sub-group of age, however, the incidence of linear fracture per age group was almost twice the multiple fracture incidence. (Table 7)

Of the 56 (32.7%) patients recorded with multiple facial bone fractures, 57 facial bone fractures were detected amongst the 24 (34.3%) paediatric patients 0 - 5 years of age, 56 amongst the 24 (31.2%) children 6 - 10 years of age and 19 were recorded amongst the 8 (33.3%) patients 11 - 15 years of age. Thus, the multiple facial bone fracture incidence of 2.38%, 2.33% and 2.38% per patient, in children 0 – 5 years, 6 – 10 years and those 11 – 15 years of age, indicate a similar incidence amongst all 56 children under 15 years of age.

Also, the total non-displaced fractures were significantly higher in both numbers and incidence than the displaced fractures documented in both sub-groups 0 – 5 years and 6 – 10 years of age. In the older children of 11 - 15 years of age, the total number of displaced versus non-displaced fractures were almost equal. (Table 7)

Compound fractures and those fractures with associated crepitus appeared in children above the age of 6 years. However, 14 (46.7%) comminute fractures, which were the most per age group, appeared in children 0 - 5 years of age, whilst 11 (36.1%) comminute fractures were recorded in children 6 - 10 years of age and the least of 5 (16.7%) were noted in children 11 - 15 years of age. Thus, a decrease in the rate of comminute fracture incidence occurred with age.

Table 7 illustrates type of fractures according to age

	<0-5 years		**6-10 years**		**11-15 years**	
Type of fracture	**N**	**%**	**N**	**%**	**N**	**%**
Linear	46	65.7	53	68.8	16	66.7

Multiple	24	34.3	24	31.2	8	33.3
Total	**70**	**100**	**77**	**100**	**24**	**100**
Displaced	13	20	15	20.8	11	47.8
Non-displaced	52	80	57	79.2	12	52.2
Total	**65**	**100**	**72**	**100**	**23**	**100**

Facial side of fracture

Of the 171 patients, 34.5% had a facial bone fracture injury on the left side, whilst 31.0% of the patients, showed a facial bone fracture injury on the right side. Twenty-one point one percent of patients had bone fractures on both the left and right side of their face. A minor group of 7.6% of patients presented with midline facial fractures. The facial side of fracture was not indicated in 5.8% of the children's records.

Associated teeth injury

Forty-nine (28.7%) patients had an associated tooth injury, whereas 122 (71.3%) showed no teeth affectation. Teeth that were mostly affected included the anterior maxillary and anterior mandibular incisors and canines of either the primary or permanent dentition. Injury to molars of the primary dentition was also noted.

The types of dental alveolar injury that were documented, either included mobility, avulsion, displacement, intrusion, root fracture, crown fracture or any pulpal involvement of the affected teeth. Mobility of teeth, where the most common dental alveolar injury noted in 28 (57.0%) patients. Avulsion of teeth was the second most common dental alveolar injury noted in 11 (22.4%) children, followed thirdly by tooth displacement detected in 6 (12.0%) paediatric patients. Sixteen (33.0%) of the 49 patients with associated tooth injury had multiple dental alveolar injuries.

Associated facial soft tissue injuries

The most commonly associated facial soft tissue injuries (STIs) observed were lacerations, abrasions, contusions, stab wounds, animal bites, hematomas, oedema (peri-orbital), soft tissue swellings, haemorrhage, ecchymosis/raccoon eyes, bleeding/epistaxis or degloving injuries. Facial soft tissue injuries were also recorded as extraoral or intraoral. Of these STIs, 396 (91.0%) were detected extra orally whilst only 39 (9.0%) were detected intraorally.

Forty-three (25.0%) children presented with a single associated facial STI, whilst 128 (75.0%) patients had multiple associated facial STIs.

Overall, 435 associated facial STIs were detected amongst the 171 children. The most commonly found facial STIs were lacerations, abrasions and soft tissue swellings, each comprised 19.5% of all STIs detected, followed second mostly by associated facial haematomas and facial oedema's. Although only 2 (0.5%) facial sites of haemorrhage were recorded, records state that another 35 (8.0%) facial soft tissue sites of injury were actively bleeding on arrival of patients. Soft tissue contusions and presentations of ecchymosis were also identified. Five (1.1%) patients in this study, had an associated degloving facial STI whilst 8 (1.8%) other STIs were included. (Figure 5)

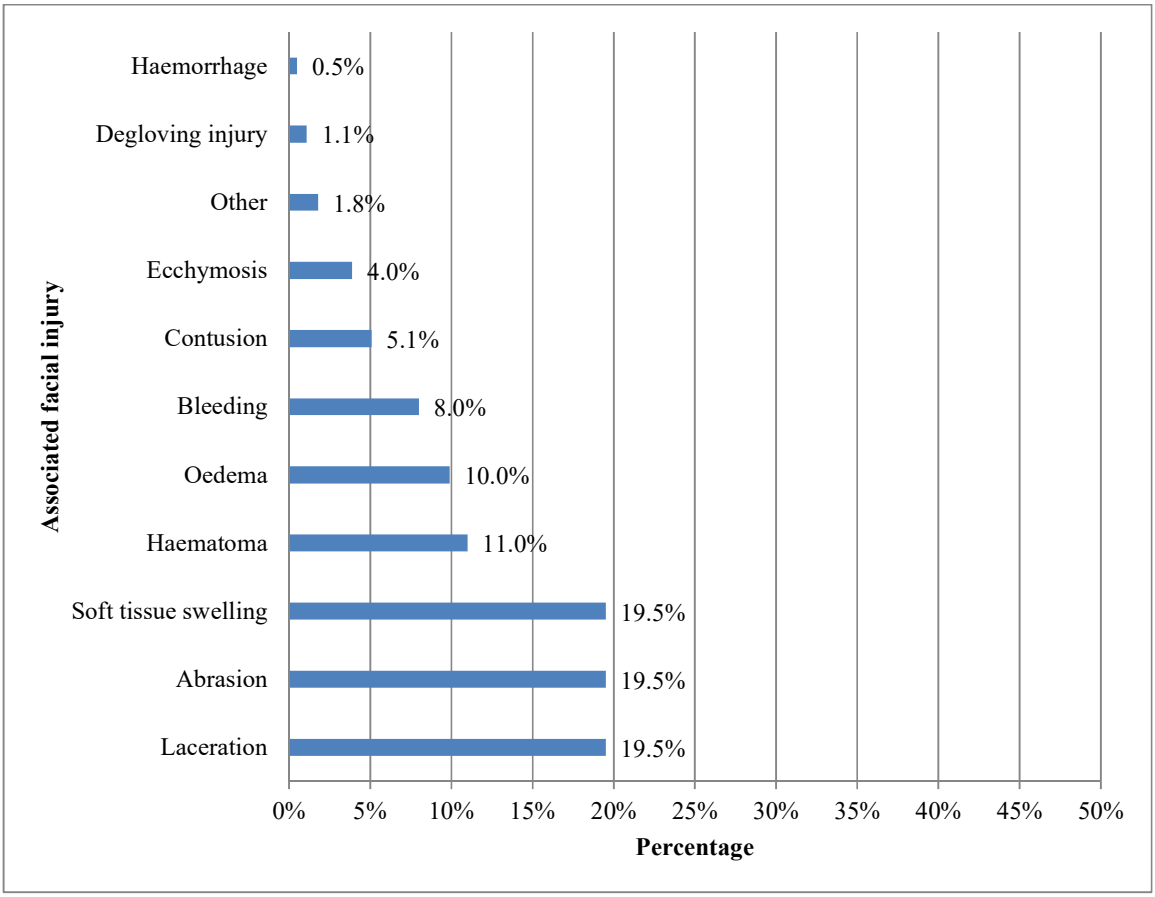


Figure 5 demonstrates associated facial injury (N=435)

Associated bodily injuries

Other bodily injuries associated with the incidence of facial fractures due to trauma, were also documented. These types of associated injuries included injury on the head (which either

involved the dura mater, skull/vault or brain/meninges), to a sinus (which indicated any involvement, opacification or heamosinus), any other body part such as the neck, lung, chest, abdomen, back, spine, shoulder, arm, hip, leg, hand or foot or other type of life-threatening injuries such as an airway involvement or obstruction.

Of the 171 patients, 43 (25.0%) patients only had a single associated bodily injury, whereas 74 (43.0%) patients were admitted with multiple bodily injuries associated with facial trauma. These bodily types of associated injuries were not indicated in 54 (32.0%) of the patient records.

Of the total 278 associated bodily injuries, the 39 (14.0%) bony skull injuries together with the 39 (14.0%) cases of sinus involvement were the most. Thirty one (11.1%) dura mater (extra- or subdural) and 16 (5.8%) brain injuries were noted. Other associated bodily injuries noted with facial fractures involved 1 (0.4%) neck, 6 (2.2%) spine, 24 (8.6%) shoulder, 7 (2.5%) hand/feet, 17 (6.1%) lung/chest, 13 (4.7%) abdominal and 25 (9.0%) hip injuries. Six (2.2%) patients with an obstructive airway were admitted.

Other symptoms recorded were excessive pain noted in 32 (18.7%) children whilst 9 (5.3%) patients with nerve damage or numbness of a bodily part were detected.

Associated ophthalmic or globe involvement

Another finding noted in this study is that 12 (7.0%) of the 171 patients showed results of ophthalmic or globe involvement. A remarkable 159 (93.0%) had no involvement. Six (50.0%) of those patients with globe involvement were between 0 - 5 years of age, 4 (33.3%) between 6 - 10 years of age and 2 (16.6%) between 11 - 15 years, which show by implication a gradual decrease in ophthalmic or globe incidence with age. This result is compatible with the decrease in orbital bone fracture incidence with age, revealed in this study.

Specialized consultation

Other medical specialists in the departments of either neurology, opthalmology or ENT (Ear, nose, and throat) have also been consulted. One hundred and twenty-nine (75.4%) children required specialized consultation from either of these departments.

Consultation with the department of neurology has been permitted solely to 41 (24.0%) patients with facial bone fracture, followed by the department of ENT in 17 (9.9%) cases and the department of opthalmology in 12 (7.0%) patients. The department of opthalmology together with the department of neurology have been included in 39 (22.8%) cases whilst 12 (7.0%) paediatric patients needed consultation from all 3 departments (opthalmology, neurology, and ENT). Four (2.3%) children required a combined specialist consultation from the departments of opthalmology and ENT and so have another 4 (2.3%) needed combined consultation from the departments of neurology and ENT.

The ophthalmology department was consulted with 119 (48.1%) of all the facial fractures (n=247), mostly for fractures of the orbital bone (34.5%), frontal bone (31.1%) and the maxillary bone (13.4%). Fewer ophthalmology examinations of which the inclusion ranged from 7.5% to 1.7% were needed for facial fractures of the zygoma, nasal bone, mandibular and Le Fort fractures.

The department of neurology has mostly been approached in 144 (58.3%) of all the fractures (n=247), which concluded to 44.4% for frontal bone, 27.1% of orbital bone and 9.7% of maxillary bone fractures. Zygoma, nasal, mandibular, Le Fort and palatal bone fractures occupied 0.7% to 6.25% of all the neurology consultations.

Specialist involvement from ENT was included in 53 (21.5%) facial fractures cases, which mainly involved fracture of the nasal, maxillary, orbital, mandibular and frontal bones. These fractures reserved 32.1%, 20.7%, 17.0%, 13.2% and 11.3% of all ENT consultations, whereas 3.8% and 1.8% of all ENT consultations were reserved for Le Fort and zygoma fractures.

Radiographs

Selective radiographs taken either included a panelipse (PAN), lateral skull, posterior-anterior (PA) or occipito-mental (OM) x-ray, Townes view, Waters view, CT scan (of the brain, spine, abdomen, chest, arm, leg, or pelvis) or an abdominal FAST (FAST: Focused assessment with Sonography for trauma). These radiographs were used as part of a diagnostic tool/measure to confirm the clinical or radiographic diagnosis of a facial bone fracture. Radiographs were documented in the records of 159 patients. A total of 401 radiographs was taken amongst this study group (12 patient records didn't indicate any radiographs). CT scans were the most widely used radiograph. A significant total of 287 (71.6%) CT scans were

taken amongst the 159 indicated patients. CT scans of the brain, spine, abdomen, chest, arm, pelvis or leg have been taken of different patients to confirm fracture as well as any associated injuries. CT scans of the brain and spine were recorded mostly which comprised 127 (44.3%) and 105 (36.6%) of all CT's taken. The remaining 55 (19.1%) CT scans were mainly taken for the associated bodily injuries of which 5.6% comprised CT of the abdomen, 3.5% of the pelvis, 2.4% of the chest, 1.4% of the arms as well as 1.4% of the legs. However, 4.9% of the total CT scans taken were unspecified.

Remarkable less two-dimensional (2D) views were taken, compared to the CT scans. The PAN comprised of 30 (7.5%), whilst 24 (6.0%) PA's, 14 (3.5%) lateral skull's, 4 (1.0%) Townes views, 1 (0.2%) Waters view and 1 (0.2%) OM were taken. Five (1.2%) other radiographs and 22 (5.7%) abdominal FASTs were taken. (Mentioned before, radiographs were not indicated in the records of 12 patients).

Thirteen (44.0%) PAN's were to confirm mandibular fracture, whilst 10 (35.0%) PAN's were conclusive of maxillary fractures. One (4.7%) PAN was reserved for a fracture of the orbit, zygoma, palate and nasal bone respectively. Most of the 14 recorded lateral skull radiographs, were to confirm fracture of the mandible (36.0%) or maxilla (23.0%). Lateral skull views indicated 9.0% fracture of the frontal bone, the orbital and the nasal bones as well as Le Fort fractures. Of the 24 posterior-anterior (PA) views taken, 46.0% were diagnostic of mandibular fracture, 19.0% of maxillary fracture whilst PA views were also conclusive of frontal, orbital, palatal, nasal bone and Le Fort fractures.

Management

Management of the 247 various facial fracture sites, resulted in the execution of 216 various treatments. However, 4 (2.3%) of the patient records did not indicate any treatment which concludes with 1.9% of the total treatments. Most patients which comprise 109 (63.7%) patients with facial bone fractures were managed conservatively. This resulted in a striking 109 (50.5%) of all 216 treatments delivered. Conservative management mainly included a non-surgical approach with observation, the administration of medication and follow up. The remaining 58 (34.0%) patients were managed by surgical intervention. Thirty-three (15.3%) facial sites of fracture were only debrided. Twenty-four (11.0%) treatments comprised the extraction of affected teeth. It therefore, seems that 24 of the 49 patients with an associated tooth injury had an affected tooth or teeth in the site of mandibular or maxillary bone fracture that had to be extracted. Sixteen (7.4%) treatments concluded to a closed reduction of facial bone fracture whilst management by open reduction resulted to 14 (6.5%) of the total treatments. Other facial or head surgery constituted 16 (7.4%) of the total management procedures. No long term results were obtained from patient records. (Figure 6)

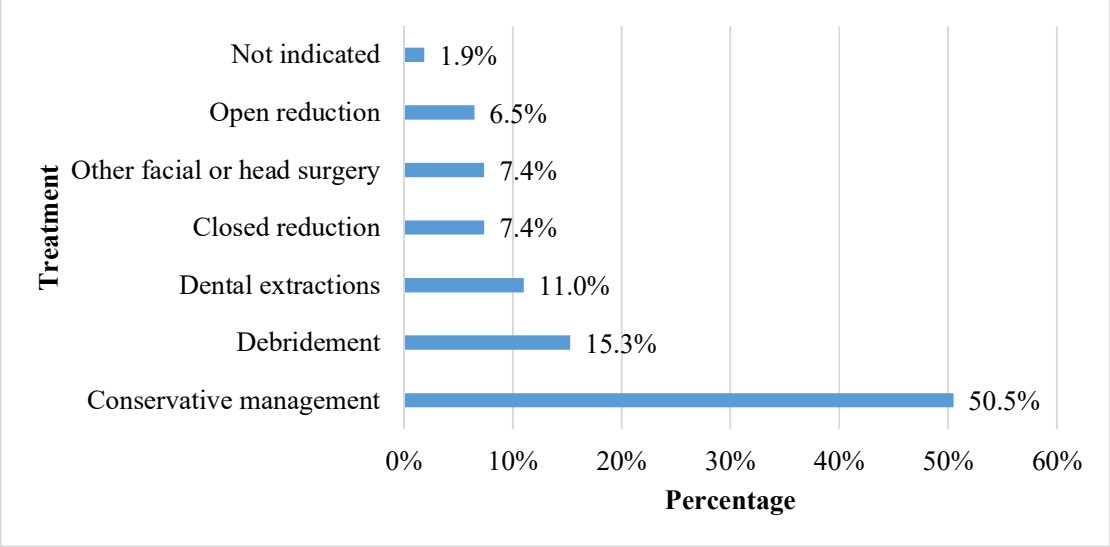


Figure 6 demonstrates how fractures were managed (N=216)

**** Conservative management = no surgical intervention + medication + follow up.**

CHAPTER 6: DISCUSSION

The size of this study population is smaller than a similar South African study approximately 20 years ago that included a sample size of 328 patients. [33] Compared to other global surveys, the facial fracture prevalence of 4.22% in this study appear to be lower than the 11.5% reported by Gassner et al, [1] 6.0% by Collao-González et al, [2] 4.6% by Imahara et al, [6] 19.0% by Chan [13] and Hyder et al [37], 12.0% by Al-Manik [34] and 12.8% by Kotecha et al. [47] From an author's perception the variance in prevalence from the above mentioned studies presumably results from changes in the methodology, which involved a different level of hospital, either extended over a longer period of time, included more than one hospital or city or covered a larger metropolitan area. The data collected in this study was from a tertiary hospital.

The mean age was 6.45 ± 3.47 years which is noticeably younger than the mean age by Gassner et al who reported the highest facial fracture incidence in children at the age of 9.7 ± 4 years. [1] Of the 247 recorded facial fractures in this study, most were detected in children 6 - 10 years of age (45.0%), followed by those 0 – 5 years of age (41.0%) and the least in children 11 - 15 years of age (14.0%), which conclude that most facial fractures occurred in children under 10 years of age. These findings show a discrepancy from related studies that detected a peak in facial fracture incidence in children between 10 – 15 years of age. [3, 14, 17, 18, 19, 23] Indian studies by Kumaraswamy et al [8] and Karim et al [16] determined a higher incidence in children 7 – 12 and 5 – 12 years of age. Jung indicated a peak in facial fracture incidence in children 13 – 17 years of age, [48] which markedly vary from the 14.0% incidence result obtained in this study of children 11 – 15 years of age. Various literature supports that the proportional incidence of maxillofacial fractures increases with age, [6, 22, 23, 34, 37, 47] which is in contrast to the author's results which possibly suggests earlier exposure of children to the external environment compared to other studies.

PVAs together with MVAs were the major cause of facial fracture amongst children 6 – 10 and 11 – 15 years of age, which concur with some of the literature [4, 5, 6, 21, 22, 24, 25, 27, 28, 37] but also vary from other studies that reported falls, violence or bicycle accidents as the major cause of injury. [2, 7, 8, 9, 13, 14, 18, 23, 28, 37, 46, 47] In this study falls, PVAs, MVAs, sports injury, violence and injury by an object to the face were the most common cause of facial fractures in paediatric males, which from the author's point of view, possible result from being more involved in vigorous play, physical outdoor activities and contact sports. However, most

females were involved in PVAs, MVAs, falls and violence. More paediatric males obtained a facial fracture injury during MVAs and PVAs than females. Although more cases of PVA than MVA were detected in both male and female children, an almost equal number of males and females were involved in MVAs. Even though injuries due to motor vehicles were separated into MVAs and PVAs, these injuries constituted the most common cause of paediatric facial fractures in this study, which concur with other studies. [6, 22, 23, 37, 45, 46]

Compared to other local studies that separated PVA and MVA, the findings in this study concurred with Lalloo et al [46] but differed from Bamjee et al who reported MVAs to be more common in children.[33] Secondly, the author's results are in sharp contrast to Bamjee et al that reported violence as the most common cause of facial fractures in children.[33] Since this study and the one by Bamjee et al were conducted in the same city, albeit 2/3 decades apart, the increase of PVA as the cause, might be attributed to political change that led to the influx of young people to the cities in search for opportunities. An anecdotal evidence suggests that lack of recreational facilities and an increase in the informal settlement areas in Johannesburg could be an explanation for PVAs being the most common cause of facial fractures. Other factors from the author's perception contributing to the high prevalence of MVAs and PVAs as major aetiological factors amongst children in these affected communities could be the negligence of drivers, lack of road safety awareness, insufficient pedestrian safety measures, inadequate parental control or lack of parental supervision. Yet, the author would like to know what these children were taught in terms of road safety and traffic rules? Besides being a possible lack of parenting skills, education, public or passenger safety, could the remarkable higher incidence of PVAs amongst children be the result of children that act without showing any signs of obedience, discipline, hesitance or judgement?

The author determined falls as the second greatest cause. A remarkable 83.0% of all paediatric facial fractures resulted from PVAs , MVAs and falls, which relate to previous studies that indicated such high prevalence of MVAs together with falls (as the second major cause of fracture). [22, 23, 29] A study done in Seattle support the highest incidence of MVAs and falls in toddlers (0 – 4 years of age). [6] However, other literature indicated falls as the major cause of facial fracture injury in children, [2, 8, 14, 18, 37, 46, 47, 49] followed by MVAs as the second major cause. [8, 14, 16, 37, 49]

Nearly 30.0% of all males and females obtained a facial fracture during falls, whilst a much smaller number of facial fracture injuries resulted from playing sports, bicycle accidents,

violence or abuse or the face being hit by an object or gate. The author's outcome oppose to the results obtained by Gassner et al that reported play accidents followed by sporting accidents as the leading causes of facial fractures in children under 15 years of age. [1] A study from Japan reported bicycle accidents followed by falls as the main causes, [17] which from a South African informal settlement perspective clearly indicate a distinct variance (e.g. in the mainstream mechanism of transport and pedestrian safety measures). A Korean study reported a 38.0% incidence of violence as the most common cause of facial fracture with a 91.0% male predominance, [19] which is far more than the 11.3% female incidence and 3.7% male incidence due to violence obtained in this study. However, this study not only revealed a higher incidence of violence amongst children 11 – 15 years of age, but also showed a higher incidence of facial fracture due to violence in females which prompt the author's suspicion that teenage girls with age, become more exposed to violent activities and abuse at their homes or nearby home environment.

In this study, a significant association between age and cause of fracture was determined by making use of the Fischer's exact test which showed a P-value of 0.01. Thus, from the author's perspective and with regards to previous studies, the age at which facial fractures occur in children is defined by the role of current, type, and degree of physical activity at a specific age, the effect of social environment and most possible the effect on behaviour and parental supervision. Mechanism of transport distinct from one country to another markedly has a definitive impact on the prevalence of paediatric facial fractures.

In terms of the association between cause and age, MVAs with PVAs were the major cause of facial fracture in all related sub-groups of age (0 – 5 years, 6 – 10 years and 11 – 15 years), especially in children under the age of 10 years. More cases of PVAs than MVAs were noted in all age-groups. In accordance with Zhou et al, [49] falls was more apparent in children under 10 years of age, with the highest rate of incidence found in children 5 years and younger, which concur with other study reports. [3, 33, 45] Falls as a major cause of facial fractures in children, which decrease in incidence with age, correlate with the literature regarding better development and control of motoring skills in older children and lack of defence mechanism in the very young. [7, 28] Sports-related facial fracture injuries essentially affected children from the age of 6 years, although most occurred in children above 10 years of age. This finding affirm the higher incidence of sports-related facial fracture injuries with age. [8] More

children under 10 years of age obtained a facial fracture injury from being hit by or with an object, although a higher incidence occurred above 10 years of age. This result corresponds to a study conveyed in Dunedin where "being hit by an object" was indicated as the main cause of injury especially in older children. [48] The high prevalence of facial fractures that occurred in black African children comprised more than 80.0% of the study population, which is from the author's point of view a direct dissemination of the drainage area of the CMJAH. The majority of this study population were male (63.7%), which agree with previous publications that also show a higher facial fracture incidence in male patients in almost all age groups worldwide. [1 - 4, 6, 8, 14, 16 - 18, 22, 23, 33, 34, 37, 45 - 49] The data analysis revealed a female to male ratio of 1:1.75 which correlate with a study by Singh et al, [29] that determined a ratio in males of approximately twice as frequently to females.

Although more facial bone fractures were detected amongst males, the fracture incidence of various bone sites between male and female were closely ranged, which resulted in a less than 1-3% discrepancy. In terms of prevalence by age, the author concurs that the aetiology of facial fractures seems to be more similar in male and female children at a younger age and that more substantial variations in aetiology occur between sexes during adolescence.

The author strongly proposes 'home' and any 'other place' or environment where children played or visited as high-risk areas for paediatric facial fracture injuries, compared to schools (lower risk areas) where children are being monitored most of the time in class, during sporting and other extramural activities. The author's results correspond with Kumaraswamy et al [8] and Hyder et al [37] which described the home as the most frequent place where facial fractures are sustained by children. From an author's perspective, the possible factors that contribute to home and other places as high-risk areas for facial fractures in children could either be lack of parental control, supervision, and responsibility, or the absence of safety measures.

In terms of seasonal variance, a higher frequency of maxillofacial fracture in children during the months of January to April and October to December were noted. This seasonal variance corresponds with other literature. [1, 2, 19, 20] This study result seems to coincide with an increase in the outdoor activity of children living in or close to this part of Johannesburg during the months of summer.

The 1.4 average fracture incidence per patient (247 facial bone fractures amongst 171 children) is close to the 1.3 average obtained from a study in Lagos, Nigeria [23] as well as the

1.2 average result detected in a study by Mansour. [14] The frontal bone followed by the orbital bone was the most common fracture site. These results concur with Van As et al that reported the orbit and frontal bone as the major sites of fracture in children. [45] A lower incidence of maxillary and mandibular bone fractures were detected. However, the author's result is in strong contrast to many other studies that determined the mandible (and in some instances the maxilla /mid-face as second mostly) as the most familiar facial bone site of fracture in children. [1, 3, 6, 8, 14, 16, 17, 18, 22, 23, 33, 48] Zhou et al concluded the highest incidence of mandibular fracture amongst children younger than 12 and adolescents above 13 years of age but also remarked a higher incidence of maxillary / mid-facial fractures amongst adolescents. [49]

More frontal bone fractures were associated with the orbit and parietal bone than with the sphenoid, ethmoid, zygomatic and temporal bones. More orbital fractures occurred on the superior border than the inferior border and medial walls, whereas least were reported on the lateral walls, which is different from a Korean study that reported the medial wall as the predominant site of the fracture. [19]

Most of the zygoma fractures recorded included the zygomatic arch, followed by inclusion of the fronto-zygomatic or tempero-zygomatic sutures. The zygomatic – maxillary complex was least included. Of all the maxillary fractures, the maxillary alveolus was mostly fractured. Parts of the mandible that were mostly fractured included the condyles (supported by Ferreira et al, [22] Kotecha et al [47] and Zhou et al [49]), body and symphysis. Other parts of the mandible were less affected fractured. Imahara reported a higher fracture incidence of the symphysis, body, and angle.[6] Kambalimath et al, Ogunlewe et al and Singh et al detected the highest fracture incidence of the mandibular parasymphysis. [3, 23, 29] Various literature also reported the mandibular condyles followed by the parasymphysis mostly affected, [8, 14, 17, 18] compared to Karim et al that detected the symphysis and parasymphysis as the common mandibular fracture sites. [16]

Most of the frontal and orbital bone fractures occurred in patients under the age of 10 years, especially in those younger than 5 years of age. A decrease in frontal as well as orbital bone fracture incidence with age was noted. With regards to the frontal and orbital bones, (firstly being the bone sites with the highest fracture incidence, secondly being the predominant facial fracture sites in younger children, especially under 5 years of age, and thirdly showing a decreased fracture incidence with age), the author also strongly appreciate the representing anatomical development of a young child's skull. The larger skull with its greater volume at

birth and early years of childhood has a more protrusive protecting position compared to the smaller retruded face of a young child. [2, 5, 6, 18, 21, 22, 23, 25, 28 - 31]

The frontal and orbital bone as the most frequently fractured sites, justify the result that more than 80.0% of the paediatric patients included in our study, were under 10 years of age. The outcome of this study thus correlate with the lower incidence of midfacial fractures and a higher incidence of cranial fractures detected in early childhood. [21, 27, 28, 30]

Zygomatic and maxillary fractures were mostly detected in children 6 – 10 years of age, with a corresponding incidence rate in those 11 - 15 years of age, but least in children younger than 5 years of age. Palatal bone fractures were only noted in children 6 – 10 years of age. An equivalent number of mandibular fractures were detected amongst all children below 10 years of age, although the highest incidence appeared in children 11 – 15 years of age. The author's results regarding the high incidence of zygomatic, maxillary and mandibular bone fractures detected in older children, which increase with age, correlate with the physiological development of facial growth in a downward and forward direction, resulting to further prominence of the midface and the mandible. Therefore this study accord to the literature which states that this particular development, may ensue a decrease in cranial and frontal bone fracture incidence and a possible increase in mandibular fracture due to its relative prominence as well as midface and orbital floor fracture due to the aeration of the maxillary sinus. [5, 6, 18, 21 - 23, 28, 31] More nasal bone fractures appeared in paediatric patients above 6 years of age, particularly in children 11 – 15 years of age. The 96.4% nasal bone fracture incidence by Collao-González et al [2] and 69.0% by Kim et al [19] is remarkable higher than the author's results of 10.9%. This variance in nasal fracture incidence most possible result from method of injury. Conversely, Imahara reported nasal and maxillary fractures as the most common in infants (0 – 1 year of age). [6] This study reported one Le Fort fracture in a child under 5 years and one in a child above 5 years of age, compared to Ferreira et al that only detected Le Fort fractures in children above the age of 10 years. [22]

More single linear than multiple fractures were detected in this study with a similar ratio of approximately 3/2 in both male and female. This result corresponds Mansour et al, [14] Ferreira et al, [22] Ogunlewe et al ,[23] a South African study by Bamjee et al [33] and by Van As et.al. [45] However, only singular fractures were detected in a study by Collao-González et al. [2] Reports from a study in China revealed a higher incidence of singular fractures in children under 12 years of age but a greater incidence of multiple severe fractures amongst

adolescents above 13 years of age. [49] Most linear fractures appeared in children 6 - 10 years of age, whereas a higher incidence of multiple fractures was detected with age. The discrepancy between linear and multiple fractures was less significant in patients 0 - 5 years of age than in older children. The multiple facial bone fracture incidence of 2.38%, 2.33% and 2.38% per patient, determined in children 0 – 5 years, 6 – 10 years and those 11 – 15 years of age, indicate a similar incidence amongst all 56 children under 15 years of age. This result encourage the author to support the literature which substantiate that the unique anatomic features of children confer greater intrinsic elasticity and flexibility on the paediatric facial skeleton. Children thus benefit in such way that they are more likely than adults to sustain greenstick or incomplete fractures and fractures that are likely to have less multiple communications. [26, 27]

Most fractures were non-displaced. Thirty-nine (22.8%) children had facial fractures that showed signs of displacement. The number and incidence of non-displaced fractures were higher in children under 10 years of age, although an almost equal number of displaced and non-displaced fractures were detected in children above 10 years of age. The author agrees that the higher occurrence of non-displacement in especially younger children coincide with the literature regarding the unique anatomic features of children which substantially affirm the greater intrinsic bone elasticity and flexibility in children. [1, 3, 5, 6, 17, 18, 19, 21-23, 25-28]

Only 49 patients (28.7%) had associated tooth involvement, of which 33.0% presented with multiple dental alveolar injuries. Teeth affected mostly included the anterior maxillary and mandibular incisors and canines of either the primary or permanent dentition, and in fewer cases, the primary molars. Mobility of teeth, was the most common associated dental alveolar injury, although subluxation of the teeth was confirmed by various studies as the most frequent dental alveolar injury. [1] The second most common associated dental alveolar injury was avulsion of the teeth followed by displacement.

Four hundred and thirty-five associated facial soft tissue injuries (STIs) were detected. Most associated STIs (91.0%) were extra orally. This corresponds to the 8.0% intraoral STI report of Collao-González et al, [2] although a study in Dunedin reported a 52.6% oral cavity STI inclusion. [48] Most paediatric patients (75.0%) with facial fractures had multiple associated facial STIs. The associated facial STI result from this study was significantly higher than the 45.9% incidence detected by Imahara et al, [6] the 29.0% - 56.0% STI incidence by Kamaraswamy et al, [8] the 21.0% by Kim et al [19] and the 64.5% STI result from a study in

Portugal. [22] Lacerations, abrasions and soft tissue swellings were the most commonly found facial STIs, which correspond with results by Gassner et al [1] and Lalloo et al. [46] Facial haematoma or oedema both comprised 10.0% of all associated STIs, whilst 8.0% of all facial STIs were actively bleeding on arrival of the patients. Haemorrhage, contusions, ecchymosis and degloving facial STIs were also detected.

Sixty eight percent of the paediatric patients had associated bodily injuries, which is remarkably higher than the 11.0% incidence reported by Collao-González et al, [2] and which is double from the result by Van As et.al. [45] This discrepancy from the author's point of view, most possible result from the difference in mechanism of injury (high impact velocity versus low impact velocity force). More children with facial fracture trauma had multiple associated bodily injuries (43.0%) compared to those with a single associated bodily injury (25.0%). A total of 278 associated bodily injuries was detected. Records revealed that bony skull injury and sinus involvement both with a 14.0% incidence are the associated injuries, mostly detected, followed by a lower incidence of extra- or subdural and brain injuries. Imahara et al also reported skull base fractures, brain injuries, cranial vault fractures and head injuries to be frequent amongst toddlers 0 – 4 years of age. [6] The high incidence of the associated skull and sinus injuries correlate with the high frontal bone fracture incidence, especially amongst children under the age of 10 years, which were mostly involved in PVAs. Other commonly associated injuries noted involved injury to the neck, airway, spine, lungs/chest, shoulders, abdomen, hips, hands and feet.

Only 12 (7.0%) paediatric patients showed signs of ophthalmic or globe involvement, most were between younger than 5 years of age, whereas the incidence appeared to gradually decrease with age.

Paediatric facial fractures were managed, in both the departments of general surgery and maxillofacial and oral surgery according to the extent of injury. Management of facial bone fractures in children involved in this study either included one or more of the following treatments:

- Conservative management, which included non-surgical intervention with observation, medication and follow-up;

- Open reduction, which either constitutes one or more of the following entities: open reduction/internal fixation (ORIF), maxilla-mandibular fixation (MMF), inter-maxillary fixation (IMF), plates, screws, bioresorbable plates, arch bars, post-op elastic traction, circum-mandibular wire or any other surgical intervention;
- Closed reduction, which either constitutes closed reduction maxillary fixation (CRMF), IMF, MMF, an acrylic splint, Interdental wires, arch bars, circum-mandibular wire or elastics;
- Observation where no other treatment is required;
- Medication (analgesics/antibiotics);
- Extractions;
- Debridement of fracture site or
- Any other facial / head surgery.

The most common type of treatment delivered to patients by the departments of general surgery and maxillofacial and oral surgery comprised of conservative management (50.5%). This conservative approach supports Karim which also concluded that the high osteogenic potential of the paediatric mandible often allows for non-surgical management to be successful. [16] Kotecha et al also confirmed that conservative management is recommended as the treatment of choice for especially condylar fractures. [47] Fifteen point three percent of facial fracture sites were debrided only whilst 11.0% of all treatments included extraction of affected teeth. Nearly half the patients with a tooth or teeth injury had an affected tooth or teeth in the site of mandibular or maxillary fracture that had to be extracted. The management of facial fractures by closed reduction, open reduction or other facial/head surgery, collectively constituted 21.3% of total treatments. This result is much lower than the 47.0% of cases from a study in Japan [17] as well as the 84.9% of cases from a study in China, [49] that were managed by open reduction. Kamabalimath et al have reported that most (83.04%) mandibular fractures were managed conservatively (IMF in 74.11% of cases and 16.7% by mini-plating) and therefore also preferred conservative management with observation as treatment of choice. [3]

Conservative management by closed reduction and MMF were the choice of treatment reported by a study in Nigeria 2003. [23] A study at the Jordan University managed 91.8% of mandibular fractures by closed reduction and 8.2% by open reduction, [14] which correspond to 7.6% open reduction treatment reported by Jung et al. [48] Kim et al reported 95.0%

management of nasal bone fractures by closed reduction. [19] This approach is supported by Ferreira et al, although 78.7% of their study sample (of which 65.0% were older than 13 years of age) received surgical treatment, including open or closed reduction. [22] Singh et al, however, described the efficient use of bioresorbable plates in the fractured mandible of children under the age of 15 years, [29] which is supported by Saikrishna et al that described the bioresorbable method of treatment as a dependable option. [36]

The author perceive correct diagnosis and plan of treatment as an imperative part of management in paediatric facial fractures. Ninety three percent of paediatric patients had radiographs of which CT scans were the radiograph of choice, especially CTs of the brain and spine. This result is in contrast to Bamjee et al who conducted a study at the same academic hospital from 1989-1992, where conventional plain films were used in general. [33] However, the study conveyed in 2006 by Van As et al also concluded CT as the gold standard in assessment of facial fractures. [45] CT as image of choice for mid-face, upper-face and intra-capsular condyle fractures is also remarked by Karim et al. [16] Most paediatric patients required specialized consultation from either the department of neurology, opthalmology or ENT. The department of neurology were consulted mostly, followed by ENT and then opthalmology. Kambalimath et al also stipulated specialized consultation by neurology as a prerequisite with craniofacial injury. [3]

Thus, from an author's perspective, the comprehensive management of paediatric facial fractures pre- and post-operative is imperative. Therefore, all specialized amenities available should be utilized to deliver comprehensive treatment. Literature accentuates the acute management of paediatric facial fractures, understanding the anatomical complexity, age-related facial anatomy and growth, critical treatment planning with consideration of post-operative effects and required expertise in treatment of facial bone fracture injuries in children [7, 13, 25, 27, 34] From the data retrieved regarding treatment and management, the author substantiate that all possible and available resources in this academic hospital have been utilized to obtain the above-mentioned principles, which besides the expertise from specialized surgeons, included the usage of CT scans and conventional radiographs as diagnostic tools for facial fractures and consultation with other specialized departments.

CHAPTER 7: CONCLUSION

In this study, most facial fractures occurred in children under the age of 10 years with a predominance in paediatric males. PVAs together with MVAs were the most common cause followed by falls, especially in children under the age of 10 years. More children were involved in PVAs than MVAs and an almost equal number of males and females were involved in MVAs. Home and other places (which include roads and any other environment besides the school that children go to) were the most common places of facial fracture injury. The aetiology of facial fractures seems more similar in male and female children at a younger age, with more substantial variations in aetiology between sexes during adolescence.

The frontal bone was the most frequent site of fracture, followed by the orbital bone. Fewer fractures of the mandible and maxilla were noted. Most fractures were non-displaced and linear/single, whereas more displaced and multiple fractures were detected in children above 10 years of age. Thus, from this study, it seems that the mechanism of injury and stage of facial development show a noticeable influence on the type and site of the bone fracture and that the frequency of aetiological factors change with age.

Less than one-third of all paediatric patients had an associated tooth injury, although more than four hundred and thirty associated facial soft tissue injuries were detected amongst all children, mostly extra-orally. Sixty eight percent of the study population had an associated bodily injury with bony skull injury and sinus involvement detected mostly. Few patient records revealed ophthalmic or globe involvement, mostly noted in children 0 - 5 years of age.

Conservative management (which comprised of a non-surgical approach, observation, medication and follow-up) were the most common type of treatment delivered to paediatric patients. Open- or closed reduction, or other facial/head surgery constituted less than 10.0% of all treatments respectively. CT scans have been used as the radiograph of choice.

Although the prevalence of paediatric facial fractures in this study was less compared to results from other related studies, and although the results were not compared with the prevalence of facial fractures in adults, the study still bears significance. Every child admitted

with a traumatic facial fracture injury, is at a specific stage of development and undergoes a unique pattern of skeletal growth. Therefore, each child with a facial fracture injury should be treated in his/her own capacity and the therapeutic approach should be with a good understanding of the patterns of anatomical growth and stages of skeletal development. Every treatment of a child who is at a specific stage or phase of skeletal growth and development, has a consequence, either aesthetically or functionally. The management and treatment of paediatric facial fractures don't correspond with the management of fractures in adults, and even the facial fractures in young children are treated differently from those in older children or adolescents. Therefore, I believe the emphasis of facial fractures in children, should essentially be on the accurate evaluation/assessment and identification of paediatric facial fractures. Not only to meet the importance of immediate treatment and intervention (due to the greater osteogenic potential, healing capacity and remodelling of bones) but also to avoid long-term disturbances or effects on the skeletal growth of facial bones.

However, noted from the records of this paediatric study population, no mention regarding sequential complications specifically, post facial fracture injury was made. These possible complications include signs of functional and aesthetic facial defects, detrimental loss of quality of life, social functioning and oral functions such as speech, mastication, respiration, and deglutition. No records revealed any signs of either permanent facial deformities or soft tissue scarring post-traumatic facial injury. Although 21.3% of the surgical treatments delivered which either included open reduction, closed reduction or any other facial or head surgery, no significant post-operative signs of destruction with regards to permanent brain injury, globe/ophthalmic injury with loss of sight, occlusal disturbances or complications to the permanent dentition was noted in the patient records. Possible long-term complications included the 5 (1.6%) patients with facial nerve damage and the 4 (1.3%) patients who had numbness of a body part. Also, no reference concerning psychological counselling, post-facial fracture injury was documented.

Furthermore, this study can possibly be used as a trend for base line data or as a platform for a next study. Through our results obtained, we could possibly contribute towards the planning of awareness strategies amongst the public, children, parents, caregivers and healthcare providers. The concern is however whether these aetiological factors of facial fracture in children result from an educational, environmental, cultural, public- or road safety matter, which needs to be addressed. Thus, the value of the work may lead to a reduction in the frequency of this type of injury, which not only results in unnecessary, possibly lifelong morbidity but enormous financial costs on a family as well as to an already stressed

healthcare system. It may also reduce mortality. The community medicine and dentistry departments, plus the department of Health should avail themselves to the data analysed and documented.

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Appendix A: QUESTIONNAIRE FOR FACIAL FRACTURE

DEMOGRAPHICS: PREDISPOSING FACTORS AND FRACTURE DYNAMICS

CMJAH: Department of Oral and Maxillofacial Surgery		CMJAH: Department of General Surgery	

Gender:	Male		Female	

Source of referral:	Parent		Guardian		Other	

Age:		Ethnicity:	
Medical history:			
Number of days between date of accident and date of arrival:			
Place of injury:	Home	Church	School

Cause of fracture	Motor vehicle accident	
	Road traffic accident	
	Fall	
	Bicycle	
	Sports	
	Violence/assault (with or without an object)	
	Abuse	
	Other	

PRESENTATION AND FINDINGS: DISTRIBUTION AND ASSOCIATED INJURIES

Site of fracture	Frontal bone					
	Orbit:	Superior	Inferior	Medial	Lateral	
	Le Fort:	I	II	III		
	Zygomatic bone:	Arch	Zygomatic-maxillary complex			
	Maxilla		Maxillary-alveolus			
	Palatal bone					
	Mandible	Symphysis	Body	Angle	Ramus	Neck
		Parasymphysis	Alveolus	Condyle	Coronoid	
	Nasal bone					

Fracture assessment		Radiographic	Palpation
Type of fracture:	Single		
	Multiple		
	Compound		
	Comminute		
	Greenstick		
Step deformity:	Displaced		

	Non-displaced		
Crepitus			

Dental-alveolar injury:	Affected teeth
Mobile	
Avulsed	
Displaced	
Intruded	
Root fracture	
Crown fracture	
Pulpal involvement	

Soft tissue injury:		Extra oral (skin)		Intra-oral	
	Laceration				
	Abrasion				
	Contusion				
	Animal bite				
	Stab wound				
	Hematoma				
	Oedema				
	Other				
	Wound description				
	Wound closure	Yes	No	Yes	No
	Method of closure				

Ophthalmic:	Globe involvement		Pupillary response	
	Loss of visual acuity		Vertical dystopia	
	Diplopia		Telecanthus	
	Ocular movement limitation		Ophthalmic abnormality	
	Ocular muscle entrapment			

	Yes	No	Site
Pre-op nerve damage:			
Numbness:			
Pain involvement:			
Bodily injury:			
Other injury:			

Specialized consultation required:	Ophthalmology	
	Neurology	
	ENT	

MANAGEMENT AND TREATMENT

Radiographs taken:		Pre-operative	Post-operative
	Panelipse (PAN)		
	Lateral skull		
	Posterior-anterior(PA)		
	Occipito-mental (OM)		

	Townes view		
	Waters view		
	CT scan		
	Other		

Treatment				**Complications/outcomes**	
Open reduction	ORIF (open reduction/internal fixation			Malocclusion	
	MMF (maxilla-mandibular fixation)			Deformity	
	IMF (inter-maxillary fixation)			Infection	
	Plates	Screws	Bioresorbable	Diplopia	
	Arch bars			Nerve damage	
	Other			Trismus	
	Post-op elastic traction			Non-union	
Closed reduction	IMF		Acrylic splint	Other	
	MMF	Interdental wires	Arch bars	None	
Observation					
Medication	Analgesics/Antibiotics				

Appendix B: Letter for ethical clearance

Human Research Ethics Committee (Medical)

Research Office Secretariat: Senate House Room SH 10004, 10th floor. Tel +27 (0)11-717-1252
Medical School Secretariat: Phillip Tobias Building, 2nd Floor Tel +27 (0)11-717-2700
Private Bag 3, Wits 2050, www.wits.ac.za. Fax +27 (0)11-717-1265

11 September 2015

To Whom It May Concern

SUBJECT: CONFIRMATION OF STUDY APPROVAL
Protocol Ref No: M150833
Protocol Title: The Epidemiology of Traumatic Facial Fractures in Children under the age of 15 Years
Principal Investigator: Dr Gerhard Fouche
Department: Oral and Maxillofacial Surgery

This letter serves to confirm that the Human Research Ethics Committee (Medical) has approved the above mentioned study. In order for a clearance certificate to be issued, the researcher is required to submit written approval to conduct the study in your district/institution.

The reseacher has been informed that this study cannot commence without your approval and receipt of the HREC (Medical) Ethics Clearance Certificate.

Should you have any queries, you may contact me at tel 011 717 1252/1234/2700 or by email Zanele.ndlovu@wits.ac.za.

Yours Faithfully,

UNIVERSITY OF THE WITWATERSRAND
OFFICE OF THE DEPUTY VICE CHANCELLOR RESEARCH
11 SEP 2015
RESEARCH OFFICE HREC (Medical)
JOHANNESBURG

Ms Zanele Ndlovu
Administrative Officer
Human Research Ethics Committee (Medical)

Human Research Ethics Committee (Medical)

Research Office Secretariat: Senate House Room SH 10005, 10th floor. Tel +27 (0)11-717-1252
Medical School Secretariat: PV Tobias Building Room 2nd Floor. Tel +27 (0)11-717-2700
Private Bag 3, Wits 2050, www.wits.ac.za. Fax +27 (0)11-717-1265

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Office of the Deputy Vice-Chancellor Research & Post Graduate Affairs

MEMORANDUM

TO: **Dr Gerhard Fouche and Dr Maphefo Thekiso**
Department of Oral and Maxillofacial Surgery
E-mail: gfouche@gmail.com

FROM: **Ms Zanele Ndlovu**
Administrative Officer: Human Research Ethics Committee (Medical)
Tel: 011 717-1252
e-mail: zanele.ndlovu@wits.ac.za

DATE: 11 September 2015

REF: ***R14/49***

PROTOCOL NO: M150833 *(This is your ethics application study reference number. Please quote this reference number in all correspondence relating to this study)*

The protocol below was considered at a meeting of the Human Research Ethics Committee (Medical) **on Friday 28 August 2015.** The Committee requires the following amendments/corrections/information from you before your application can be approved.

Project Title: The Epidemiology of Traumatic Facial Fractures in Children under the age of 15 Years

Conditions: **Approved subject to:**

- Providing written permission to conduct the study from the relevant authorities of the Wits Oral Health Centre and CMJAH CEO
- *Data Capturing Sheet:*
  - Removing identifiers i.e. dates of accident and arrival from datasheet and substituting with number of days between accident and arrival

NB:

1. **No research study can commence without receipt of the HREC (Medical) Ethics Clearance Certificate.**
2. **Please submit a covering letter (list all the conditions above and write your response below the each condition and attach relevant documentation), highlight any changes made and send two hard copies to this office. The default for submission is hardcopies –Amendments send by email will not be considered.**
3. **Amendments must be delivered at Faculty of Health Sciences, Phillip Tobias Building, second floor, Cnr York Road and Princess of Wales Terrance**
4. **Office hours: 07h30–16h00**

Appendix C: Letter from CEO of CMJAH, Ms G Bogoshi

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITAL

Enquiries:
Mr. J. Maepa
Office of the Clinical Director
Tell: (011): 488-3365
Email:Johannes.maepa@gauteng.gov.za
13 May 2016

Dear Dr. Gerhard Fouche

STUDY TITLE: The epidemiology of traumatic facial fractures in children under the age of 15 years.

Permission is granted for you to conduct the above recruitment activities as described in your request provided:

1. Charlotte Maxeke Johannesburg Academic Hospital will not anyway incur or inherit costs as result of the said study.
2. Your study shall not disrupt services at the study sites.
3. Strict confidentiality shall be observed at all times.
4. Informed consent shall be solicited from patients participating in your study.

Please liaise with the HOD and Unit Manager or sister in charge to agree on the dates and time that would suit all parties.

Kindly forward this office with the results of your study on completion of the research.

Supported/~~not supported~~

Dr. M.I. Mofokeng
Clinical Director
DATE: 16/05/2016

~~Approved~~/not approved

Ms G. Bogoshi
Chief Executive Officer
DATE: 19.05.2016

Appendix D: Letter from Head of Dental School: Prof P Hlongwa

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

WITS ORAL HEALTH CENTRE
Private Bag X15 Braamfontein, Johannesburg, 2017
Enquiries: Mrs. JC Pretorius/Ms L Huygen
Tel: (011)488-4906, Fax(011)488-4869
E-mail: Rina.Pretorius@wits.ac.za
Liza.huygen@wits.ac.za

9 December 2015

Dr G Fouche
School of Oral Health Sciences
University of the Witwatersrand
Johannesburg

REGARDING: **APPLICATION TO CONDUCT RESEARCH IN THE WITS ORAL HEALTH CENTRE**

REFERENCE: **WOHC/HREC/NOV/2015/01**

It is my pleasure to grant final approval to utilize resources at Wits Oral Health Centre in order to conduct your research. The Hospital Research and Ethics Committee allocated a unique reference number to this application – Kindly quote this reference number in all future correspondence regarding this research.

Please note that the Hospital Research and Ethics Committee should be informed of the estimated date the research will commence, as well as regular status reports until the research have been concluded. Within a month after conclusion of the research project, a written report must be submitted to the Head of School / CEO, summarizing the final results / outcome as well as recommendations made based on the research conducted.

Regards,

Prof P Hlongwa
CEO/Head of School

Appendix E: Letter from Clinical Head of Department of Surgery: Dr TE Luvhengo

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

University
of the Witwatersrand
Johannesburg

Department of Surgery:

Charlotte Maxeke Johannesburg Academic Hospital

Post net Suite #235, Private Bag x2600, Houghton 2041 • Telephone +27 (0)11 488-3373 • Fax +27 (0)11 488-4322 • Email: Thembekile.mthembu@wits.ac.za

09th December 2015

Ms. G Bogoshi
Office of the CEO
Charlotte Maxeke Johannesburg Academic Hospital

Dear CEO

Re: Research Project:

Good day. This is to inform you that Dr Gerhard Fouche is planning to conduct a study titled:

- The epidemiology of traumatic facial fractures in children under the age of 15 years.

We are aware of the study and fully support it. There will be no cost implication to the Hospital. Dr Fouche has already applied for ethical approval from the Human Ethics Committee of University of the Witwatersrand.

Yours sincerely

Dr T E Luvhengo
Clinical Head of Surgery Department
Charlotte Maxeke Johannesburg Academic Hospital